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CARIBBEAN FORESTER

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Caribbean Forester

El Caribbean Forester es una revista semestral gratuita publicada en Puerto Rico desde el año 1938 por el Instituto de Dasonomía Tropical del Servicio Forestal del Departamento de Agricultura de los Estados Unidos. Esta publicación está dedicada a promover la mejor ordenación y utilización de los recursos forestales del trópico con especial énfasis a la región del Caribe.

Provee información a los que laboran en la dasonomía y ciencias afines sobre los problemas específicos que confrontan, las políticas forestales vigentes y el progreso del trabajo que se lleva a cabo para mejorar la ordenación y utilización de los recursos forestales tropicales. También sirve como medio informativo sobre los resultados y el progreso de los programas experimentales, en ordenación forestal tropical y utilización, que se llevan a cabo en el Instituto de Dasonomía Tropical en Puerto Rico. También le brinda una oportunidad a otras personas interesadas en la dasonomía tropical para presentar el resultado de sus trabajos.

Se solicitan aportaciones de otras fuentes en el campo de la dasonomía tropical siempre que no estén considerándose para publicación en otras revistas. El manuscrito generalmente no debe exceder 20 páginas escritas a máquina a doble espacio, aunque ocasionalmente podría aceptarse un artículo más largo cuando tuviera un interés especial.

Los artículos deben someterse en la lengua vernácula del autor, deben incluir su título o posición que ocupa y un resumen corto. Deben estar escritos a máquina a doble espacio, solamente en un lado de la página, en papel blanco primera, tamaño 8½ por 11 pulgadas.

Las tablas deben numerarse consecutivamente, cada una en una hoja separada con su título. Las notas al pie usadas en las tablas deben escribirse a máquina como parte de la tabla y designarse por medio de números.

Las ilustraciones deben designarse con números y numerarse consecutivamente. Los títulos para cada ilustración deberán someterse en una página separada. Las fotografías sometidas como ilustraciones deben ser claras, bien definidas y en papel glaseado, preferiblemente 5 por 7 u 8 por 10 pulgadas en tamaño.

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Los manuscritos deben enviarse al Director del Instituto de Dasonomía Tropical, Río Piedras, Puerto Rico.

Las opiniones expresadas en esta revista no coinciden necesariamente con las del Servicio Forestal. Los artículos publicados en el Caribbean Forester pueden reproducirse siempre que se haga referencia a la fuente original.

The Caribbean Forester is a free semi-annual technical journal published since 1938 in Puerto Rico by the Institute of Tropical Forestry, Forest Service, U. S. Department of Agriculture. This publication is devoted to the development of improved management and utilization of tropical forest resources, with special interest in the Caribbean region.

Through the pages of the journal tropical foresters and workers in allied scientific fields are informed of specific problems of tropical forestry, policies in effect in various countries, and progress of work being carried out for the improvement of the management and utilization of forest resources. It furnishes a means of distribution of information on the progress and results of the experimental programs of the Institute of Tropical Forestry in Puerto Rico. In addition, it affords an opportunity for other workers in the field of tropical forestry to make available the results of their work.

Contributions for the journal are solicited. However, material submitted should not be under consideration for publication elsewhere. Manuscripts should not ordinarily exceed 20

(Continúa en la portada #3)

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Caribbean Forester

Contents

Sumario

Page

Annual Report for 1961 - Institute of Tropical Forestry ... 1

Medición del Crecimiento de los Arboles en los Bosques Tropicales ... 15
C. B. Briscoe

The Status and Development of the Nicaraguan Pine Savannas ... 21
B. W. Taylor

Report on 1961 Tropical Forestry Short Course ... 27
H. Barres

Modificación del Programa de Enseñanza ... 33
Gerardo Budowski

Forests and Dominant Legumes of the Amatuk Region, British Guiana ... 35
B. A. Whitton

Annual Report for 1961

Institute of Tropical Forestry

Looking back over 1961, the event of greatest potential significance to tropical forestry was diplomatic in character, rather than technical: the signing of the Alliance for Progress by the Organization of American States at Punta del Este, Uruguay. The Alliance is, among other things, an expression of common concern regarding the underdevelopment and misuse of natural resources in Latin America. It was a general resolution to place the solution of these problems high on the priority list, and the United States agreed to provide liberal assistance. Implicit in the objectives of the Alliance is better management of forest lands, through (1) their identificaction and classification as such in programs of agrarian reform; (2) protection from fire, irrational exploitation, and cultivation; (3) improved tenure; and (4) positive efforts to raise and sustain their productivity to a maximum.

Other events during the year further manifest growing international recognition of the need for better management of forest resources. Mexico, with the assistance of FAO, is undertaking a national inventory of forest resources. Forestry education within the region is being expanded. The Latin American Institute for Forestry Training and Research at Mérida, Venezuela, was strengthened in 1961 by financial support from seven Latin American countries. The graduate training program in forestry offered at the Inter-American Institute of Agricultural Sciences in Turrialba, Costa Rica, was expanded by a grant from the FAO Special Fund. Both FAO and the United States are assisting in the development of a new professional forestry school at Vicosa, Brazil. Basic forest research was undertaken as a result of Public Law 480 grants by the United States to outstanding scientists in Colombia, Perú, Brazil, and Chile. The government of Chile, with assistance from the FAO Special Fund, has agreed to set up a large national forest research institute.

The Tropical Forest Research Center, as the sole permanent field office of the U. S. Forest Service in the Latin American region, has watched these developments with much interest. They portend growth in the importance of forestry in Puerto Rico, where research and other efforts to solve forestry problems common to much of the region have been in progress. Many of the foresters now called upon for these expanded programs obtained part of their training in Puerto Rico. The Alliance for Progress and the new educational and research programs being undertaken signify a growing demand for foresters and technical forestry information.

General acceptance of the growing role of the Forest Service in Latin American forestry was the motive for conversion of the Tropical Forest Research Center to the Institute of Tropical Forestry this year, placing greater stress upon the international aspects of the work. Research in forest management and utilization, public forest administration, and assistance to private forest landowners have also progressed.

The Institute of Tropical Forestry was represented in the United States delegation to the Second Session of the Regional Committee on Forest Research of the Latin American Forestry Commission of FAO, held in Caracas, Venezuela, March 1961. The Director of the Institute, as chairman of the Section on Planting of the Committee, reported on two years' work in collecting data on

plantations throughout Latin America, published by the Institute as a supplement to Volume 21 of the *Caribbean Forester*. The Director was asked to continue to head the Section on Planting until a successor could be found. In this capacity he took measurements in more than 100 additional outstanding forest plantations in Trinidad, Chile, Argentina, and Brazil. Most of these data have since been published in the *Caribbean Forester*. In August the responsibility of the Institute was shifted to direction of the Section on Forest Research Evaluation of the Research Committee.

The Institute was represented also at the Second World Eucalyptus Conference, held in Sao Paulo in August, where the Director served as head of the U. S. Delegation. There, as regional reporter for Latin America, he presented a paper summarizing progress with eucalyptus in this area since the previous conference. He also submitted to the Conference: (1) summaries of data collected in more than 100 outstanding eucalyptus plantations throughout Latin America, and (2) "Statistically Valid Planting Trials," a technical paper prepared by a staff member and directed toward more effective regeneration research in Latin America.

The introduction of a section on Forestry in the Pacific Science Congress, held in Hawaii, August 21 to September 6, led to an invitation to the Institute to present a technical paper on a subject of pantropical scope. The forest management research project leader participated and presented a paper on tree measurement in the tropics.

The staff of the Institute has had the benefit of a greater number of personal contacts with tropical forestry and foresters here than in the past. In addition to the students who attended the tropical forestry short course, the Institute was host to 18 professional foresters of long experience from 11 foreign countries. The staff studied forestry firsthand in Trinidad, Chile, Argentina, and Brazil. These contacts have led to continuing technical correspondence of mutual benefit.

Forestry research for Puerto Rico and the Virgin Islands continued to be concentrated on the selection of trees for the forests of the future. Adaptability tests with recently selected species were expanded on new sites in the coffee and limestone regions. Past growth data from more than 25,000 trees, too voluminous for complete analysis by former techniques, are being reanalyzed electronically. The search for superior phenotypes is continuing and comparative tests of the properties of wood from selected trees suitable for intensive management are being planned. Early indications all point to the prospect of far superior trees for future forestry as a result of such research.

The scope of the program of the Institute within Puerto Rico and the Virgin Islands has not changed during the past year. It includes, in addition to research in forest management and forest utilization, multiple-use administration of the 27,000-acre Luquillo Experimental Forest, cooperative assistance to forestry on nonfederal lands within both Puerto Rico and the Virgin Islands, and training in tropical forestry.

The accomplishments of the Institute are in part the product of generous cooperation by a number of local agencies, industries, and individuals. Headquartered on the grounds of the University of Puerto Rico, the Institute has enjoyed scientific collaboration by the Agricultural Experiment Station of the University in the form of technical counsel by scientists on fields allied to forestry and in data processing. The Agricultural Extension Service, also of the University, has provided material assistance in the processing of photographs and numerous mimeographed publications, and in arranging field demonstrations. The Division of Forests of the Puerto Rico Department of Agriculture has worked directly with the staff on field experiments and demonstrations, and has provided

land, materials, and equipment as needed. The Virgin Islands Corporation has financed, through both grant and revolving funds, forest research work in St. Croix which otherwise could not have been undertaken. The Virgin Islands Agricultural Program provided office, nursery space, use of equipment, and technical counsel for the program there. Local manufacturers of furniture and other wood products have provided materials for forest utilization research. Sites for the testing of reforestation techniques in Puerto Rico and St. Croix were provided by more than 50 landowners.

FOREST MANAGEMENT RESEARCH

Tests of species adaptability continue to dominate the forest management research program. In the field as a whole 135 studies were active at the beginning of the year. Nine new studies were begun during the year and 75 were closed or combined, leaving the number of studies active at the end of the year at 69.

DENDROLOGY

A forest arboretum, including tenth-acre plots of each of the major species incorporated in adaptability studies, was begun late in 1960. Species added this year bring the total to forty. For a few species lack of planting stock has forced use of plots smaller than tenth-acre.

Final editorial revision of the manuscript "Arboles Comunes de Puerto Rico e Islas Vírgenes" was completed, making probable its publication by the University of Puerto Rico during 1962.

PHENOLOGY

Coordinated weekly measurements of rainfall, temperature, humidity, and circumferential growth were continued at four locations in the Luquillo Forest. Analysis of two years of data has begun.

VARIATION AND SELECTION

Additional outstanding individual trees of mahoe (*Hibiscus elatus* Sw.), teak (*Tectona grandis* L.), bigleaf mahogany (*Swietenia macrophylla* King), small-leaf mahogany (*S. mahagoni* Jacq.), and Honduras pine (*Pinus caribaea* Morelet v *hondurensis)* were located and marked for later use in progeny and clonal testing.

Attempts without auxins to root cuttings from mature trees of bigleaf and small-leaf mahoganies were unsuccessful; new leaves were produced at all three seasons of collection, but no roots were initiated.

SITE IMPROVEMENT

First-year results of fertilizing established teak plantations indicated that fertilization at all levels tested increased diameter growth. Detailed analyses will not be attempted until data for a longer period are at hand.

Early results from a second test of fertilizers showed that (1) fertilized hardwood seedlings grew significantly more rapidly than unfertilized seedlings on a well-drained clay loam; (2) fertilization caused no increase in growth on a heavy clay subsoil with a shallow hardpan; and (3) pine growth was not affected by fertilization on either site.

NURSERY PRACTICE

Large cuttings, for live fence posts, of *Gliricidia sepium* (Jacq.) Sleud and *Erythrina berteroana* Urban rooted well in March, July, and November, whereas cuttings of *Ficus laevigata* Vahl collected at the same times, rooted very poorly, in spite of the reputation of this species as a live post.

Small-scale tests indicated that fertilized teak sawdust is a satisfactory potting medium for pine, and that seedlings in polyethelene bags only 4 x 6 inches (flat dimensions) develop satisfactorily for planting stock. Both studies will be repeated on a more conclusive scale during the coming year.

Figure 1. ANTHOCEPHALUS CADAMBA at 18 months.
Left - Friable clay loam, 10 ft. Right - Poor site, 0.6 ft.

SPECIES ADAPTABILITY

Adaptability studies are now in progress at 35 test locations and with 48 species, 20 of which are pines. Twenty-two of these locations are on the lands of private cooperators, some of whom provide complete plantation care. The development of some of the trees under test is summarized in Tables 1 and 2, presenting heights measured 24 to 27 and 12 to 15 months, respectively, after outplanting. The clay soil used two years ago is clearly seen to be inferior to the clay loams planted one year ago. Site quality is seen to be very important, especially for the hardwoods. Cadam (*Anthocephalus cadamba*), for example, on the best plot averaged 2500 percent taller than on the worst plots. Although this is the extreme, differences of more than 300 percent are common. Differences in survival percentages, not given, are almost as striking.

Table 1. Tree heights[1]/ after two growing seasons.

Species	Sandy Loam Soil			Clay Soil[2]		
	Plot Max.	Means[3] Av.	Tallest Tree	Plot Max.	Means[3] Av.	Tallest Tree
			Feet			
Spathodea campanulata	16.3	5.2	22	—	—	—
Cecropia peltata	13.2	7.0	21	—	—	—
Eucalyptus patentinervis	11.7	6.9	21	—	—	—
Pinus caribaea v. *hondurensis*	7.9	5.5	17	1.8	1.6	4
Anthocephalus cadamba	—	—	—	5.1	4.8	9
Pinus caribaea v. *caribaea*	4.3	2.8	8	—	—	—
Hibiscus elatus	—	—	—	4.0	3.2	8
Schizolobium parahybum, Brazil	—	—	—	3.1	2.0	5
Swietenia mahagoni	—	—	—	2.9	1.4	4
Khaya nyasica	—	—	—	2.1	1.8	3
Enterolobium cyclocarpum	—	—	—	2.0	1.7	3
Platanus occidentalis	2.0	1.1	2	—	—	—
Schizolobium parahybum, Guatemala	—	—	—	1.5	1.4	2
Swietenia macrophylla	—	—	—	1.4	1.2	3
Tectona grandis	—	—	—	0.5	0.2	2

1/ To completed feet, therefore trees with a mean measured height of 2.0 feet have an actual average height of approximately 2.5 feet.

2/ Poor, eroded site with shallow hardpan.

3/ Each plot value was assigned unit weight in computing mean for soil type.

Table 2. Tree heights[1]/ after one growing season.

Species	Sandy Loam Soil			Clay Soil		
	Plot Means[2] Max.	Av.	Tallest Tree	Plot Means[2] Max.	Av.	Tallest Tree
				Feet		
Anthocephalus cadamba	—	—	—	12.4	4.2	16
Casuarina equisetifolia	11.9	6.4	20	8.2	6.4	15
Hibiscus elatus	10.9	4.5	15	9.5	4.9	13
Enterolobium cyclocarpum	9.8	7.3	16	6.5	5.2	11
Schizolobium parahybum, Brazil	—	—	—	8.8	5.6	11
Eucalyptus patentinervis	—	—	—	8.5	4.6	14
Pterocarpus indicus	—	—	—	6.1	4.8	11
Schizolobium parahybum, Guatemala	—	—	—	5.1	2.8	9
Cupressus lusitanica	4.5	4.5	6	4.7	2.7	7
Swietenia mahagoni, Puerto Rico	—	—	—	4.5	2.6	4
Khaya nyasica	1.5	1.0	4	4.4	2.3	7
Pinus caribaea v. *hondurensis*	3.9	2.8	8	4.1	2.4	6
Swietenia mahagoni, Jamaica	—	—	—	4.0	3.3	6
Swietenia macrophylla	—	—	—	3.3	1.8	6
Tectona grandis	2.9	1.0	12	3.3	1.7	6
Cybistax donnell-smithii	2.9	1.9	3	1.9	1.4	3
Pinus caribaea v. *caribaea*	—	—	—	2.9	2.4	6
Samanea saman	1.0	0.4	1	2.5	1.4	4
Carapa guianensis	—	—	—	4.0	2.4	6
Cedrela mexicana[3]/	—	—	—	1.6	0.8	3
Swietenia humilis	—	—	—	1.5	1.2	4
Pinus elliottii v. *densa*	—	—	—	1.5	1.2	3
Pinus occidentalis	1.5	0.9	3	—	—	—
Hernandia sonora	—	—	—	1.4	1.0	3
Pinus massoniana	1.4	0.9	4	—	—	—

1/ To completed feet, therefore trees with a mean measured height of 2.0 feet have an actual average height of approximately 2.5 feet.
2/ Each plot value was assigned unit weight in computing mean for soil type.
3/ Direct seeded.

New species or seed sources outplanted at two or more locations during the year were:

Cordia alliodora	Costa Rica
Eucalyptus	Bangalore hybrid
Khaya senegalensis	Sudan
Maesopsis emini	Uganda
Pinus douglasiana	Mexico
P. echinata	United States
P. elliottii elliottii	United States
P. michoacana	Mexico
P. montezumae	Mexico
P. oocarpa	Guatemala
P. oocarpa	Mexico

P. pseudostrobus	Mexico
P. strobus chiapensis	Mexico
P. taeda	United States
Pseudocedrela kotschii	Sudan
Taxodium mucronatum	Guatemala

GROWTH OF TREES AND STANDS

Collection of descriptions of promising forest plantations in Latin America, begun in 1959, was extended to southern South America; 110 new plantations were studied in five countries. Reports have been prepared, in both English and Spanish, and added to the previous compilation appearing as "Records of Forest Plantation Growth in Mexico, the West Indies, and Central and South America," Caribbean Forester 21, Supplement.

A study of the effect of different cutting cycles upon the yield of fence posts from mangrove naturally regenerated after clear-cutting was initiated during the year. Preliminary results indicate that in unthinned stands the production of fence-post sized trees is negligible at age 6. At 8 years the mean annual increment was 72 posts per acre, and at 10 years 276 posts per acre. Yields at greater age and from stands subjected to thinning are not yet known.

CHEMICAL ARBORICIDES

The success in Uganda of tree poisoning without the use of frills led to a study of this technique in the Luquillo Forest, where a large area is being subjected to stand improvement. The study included 80 trees of 23 species, ranging from 4 to 12 inches, d.b.h. Chemicals used were Weedone and 2,4-Dow 40, mixed on an acid-equivalent basis in diesel oil. They were applied from 1-gallon cans with nail-hole orifices in the spouts. The bark of trees not frilled was wet in a continuous band 6 inches wide around the tree at about two feet above the ground. Rainfall about 5 hours before treatment left the bark moist but not wet when treated. Six hours after treatment more rain fell. The results to date are shown in Table 3.

Table 3. Three-month and six-month effects of tree poisoning.

TREATMENT	Percent Acid			Dead		Loss of Vigor		Normal	
	2,4,5-T	2,4-D	Frills	3 mo.	6 mo.	3 mo.	6 mo.	3 mo.	6 mo.
	%	%		%	%	%	%	%	%
Current	0.89		Yes	33	67	47	13	20	20
Similar, with D	0.74	1.53	Yes	13	27	60	46	27	27
Similar, no frill	0.62	1.30	No	7	50	73	37	20	13
High T	3.00		No	33	80	60	20	7	0
High T & D	2.00	4.00	No	67	87	26	6	7	7

It is apparent in Table 3 that by increasing the concentration of 2,4,5-T it was possible to obtain as complete a kill without frills as is to be expected from the technique currently in use. No clear advantage was seen in adding 2,4-D. The added cost of the high-T solution as compared with that currently in use is more than offset by savings in frilling costs. The results further suggest that lower concentrations of 2.4,5-T may also prove

satisfactory. Additional tests will relate effects to season and to wetness of the bark at the time of application.

PILOT MANAGEMENT

More than 6,000 acres of secondary stands in the Luquillo Experimental Forest have been subjected to systematic management to increase productivity. During 1961, the sixth year of such management, the first improvement cutting was completed in all but a small area to be acquired by a land exchange. In addition, during the cycle 91 acres were reforested and 838 acres of plantations were released.

Preparatory to the next treatment of this forest a field inventory was completed during 1961 which, when fully analyzed, will be used to determine the type and priority of further silvicultural work in the various compartments. Field data were also collected to determine the abundance and quality of natural regeneration resulting from the first treatment. Results, not yet complete, indicate that natural regeneration is generally adequate in quantity, but the better species are not always well represented. Other recent data on artificial regeneration and the potential utility of a number of native woods will be used in drawing up the second management plan for this area during the coming year.

Figure 2. Post of Casuarina 18 years after treatment with Carbolineum, set in forest with high humidity and more than 100 inches annual rainfall.

The first silvicultural treatment of the pilot management area greatly benefitted the spacing of the trees and the composition of the forest. Nevertheless, the absence of high quality trees in the stands and the need to eliminate many of no value required an investment much greater than the value of the timber yield. An objective of this project in the future will be to expand utilization to a point that silvicultural work can be supported by receipts. To this end, a small utilization plant in the forest is planned, to be operated by an individual cooperator or a group organized as a cooperative. Processing will include preservative treatment of roundwood, sawmilling and seasoning of lumber, and later possibly also secondary manufacture, such as novelties and cabinet work.

FOREST UTILIZATION RESEARCH

The chief line of utilization research in recent years has been preservative treatment of fence posts. In 1961, with tests of the more promising nonpressure techniques of preservation completed, emphasis shifted to the study of service life of treated posts and the seasoning of lumber. A vacancy in the project leader position during part of the year resulted in slower progress than had been anticipated.

WOOD PRESERVATION

Posts of Casuarina (*Casuarina equisetifolia* L.) are commonly produced in farm plantations. Their service life is seldom more than 2 years. The earliest test of preservative treatment by the Institute was made 18 years ago with this species. The preservative used was carbolineum, applied by the hot-and-cold bath technique. The treated posts of this test, set beneath a forest subject to continuous high humidity and more than 100 inches of rainfall annually are still sound.

Other commonly used posts are eucalyptus (*Eucalyptus robusta* J. E. Smith), a planted exotic species; and mesa (*Micropholis chrysophylloides* Pierre), a common tree native to forests above 2,500 feet elevation. Posts of these two species, treated with carbolineum by hot-and-cold bath, are all still sound after 12 years of service on the northern coastal plain and at 2,500 feet elevation in the mountains.

More recently the promising results obtained elsewhere with simpler techniques and more convenient preservatives led to a test of the cold-soaking method, using 10 percent pentachlorophenol and posts of 57 species. After ten years of exposure, 56% remain serviceable at sea-level and 96% at 2,500 feet elevation.

A more definitive comparison of treating methods was undertaken in 1958. Posts of 52 species were treated by the cold-soaking method and 21 species by the hot-and-cold bath method, both using 5 percent pentachlorophenol in diesel oil. In addition, ten species were treated with a 50-50 creosote and diesel oil solution by both methods. Thirty species were treated by the double diffusion method with two sets of solutions: (1) sodium fluoride and copper sulfate and (2) copper sulfate and sodium chromate-sodium arsenate. Untreated posts were set as controls. After three years of exposure, both at sea level and in the mountains, 100 percent of the untreated posts have failed due to decay or termites, but no failures of treated posts have yet taken place.

SEASONING

Local lumber dealers and furniture manufacturers have long recognized problems related to the moisture content of wood. Lumber imported from different sources, or even repeated shipments from the same source, has varied widely in its moisture content at the time of arrival. Prompt use of such lumber has led to problems of checking, warping, and shrinkage during and after manufacture. To date these problems have precluded large-scale shipment of manufactured items to the

continental market. The first steps toward the solution of this problem, the use of moisture meters and air-drying for a period prior to manufacture, have been taken by some of the more progressive furniture factories. However, accelerated drying of lumber to a controlled moisture content near that which will prevail during use of the product, is not yet a common practice. On the assumption that kilns must be installed locally for this purpose, the Institute purchased a 500 board-foot experimental kiln and has begun testing schedules for the more commonly used tropical hardwoods.

Attention was drawn in 1961 to the effectiveness of tests at the Forest Products Laboratory at Madison with what was called a "solar predrier." There lumber has been dried rapidly merely by placing it in an insulated, transparent structure subject only to solar heat, with internal circulation fans and vented to permit escape of vapor. Several factors of the Puerto Rican environment suggested that such a technique might prove practical. The use of a large number of distinct lots of lumber from various sources makes desirable a technique simple and adapted for small-scale operations. Conventional kilns are expensive to operate as well as to install. The local climate is warm the year around and with some direct sunlight almost every day.

A test drier with a capacity of 2,000 board feet was constructed. The structure is about 14 feet long (east to west) and 10 feet wide.

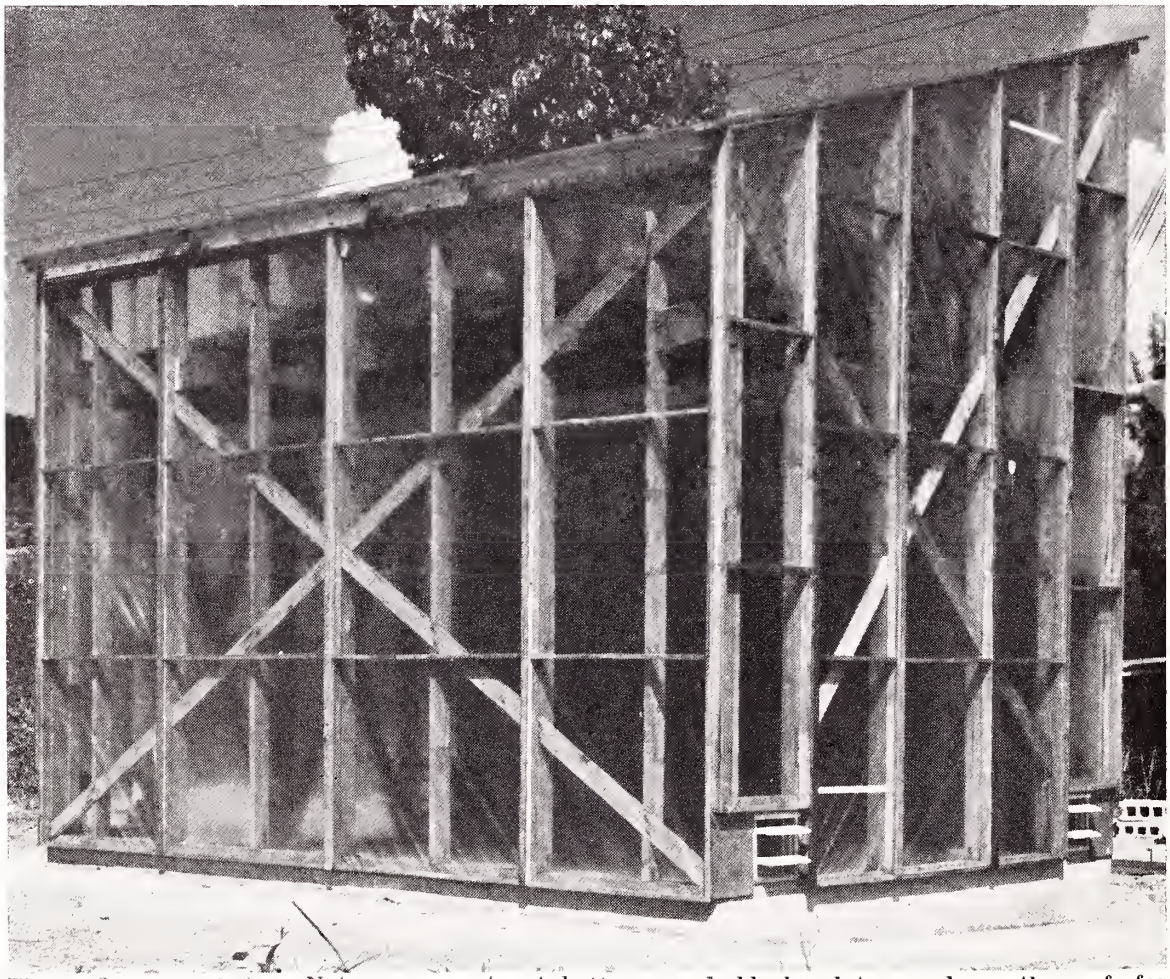

Figure 3. Solar Drier. Note open vents at bottom, and black plates underneath roof for maximum insolation.

The south wall is about 10 feet high and the north wall is 13 feet, making the pitch of the roof approximately perpendicular to the mean position of the sun at noon in this latitude. The north wall is sheathed with plywood, and the roof and all other walls are sheathed, both outside and inside, with transparent plastic film, providing a 1½-inch dead-air space. Noon air temperatures within the drier range up to 40°F higher than outside, early morning temperatures about 10°F.

The first test of the solar drier in Puerto Rico was made with 5/4 mahogany *(Swietenia macrophylla* King) with an initial moisture content of 50 percent. The lumber reached equilibrium moisture content (14 percent) in 19 days, although 14.92 inches of rain fell during the period. After 29 days, the moisture content had dropped to 8.5 percent, while a comparable roofed pile outside retained 29 percent. Subsequent tests have shown even more rapid drying possible during better weather. Drying defects, mostly end-checking, were more pronounced in the pile outside than in that inside the drier.

Experience to date indicates that solar drying can be so effective that no kiln drying need follow its use. Much interest has been shown in this process by the local wood industry. For further tests the structure is to be enlarged to accommodate longer material.

FOREST ADMINISTRATION

The Luquillo Experimental Forest, while devoted primarily to research, continues as an increasingly important example of multiple-use public forest land management in the tropics. Its geographic location between the United States and much of Latin America enhances its value to visitors from both areas as a demonstration of the results of good forestry. Both the demand for more intensive use of this area and the number of visitors are increasing rapidly.

Studies of virgin forest ecology, silviculture of naturally established forests, reforestation, plantation management, and watershed management are either under way or planned for tracts distributed throughout this forest and covering more than half its total area of about 27,500 acres. During the past year a study of natural regeneration was intensified on 300 acres. A study of stand characteristics was begun on more than 6,000 acres as a preliminary to intensification of pilot management on this entire area.

Timber management is also being intensified. The established plantations, mapped in 1960, are being subjected to drastic release of selected crop trees for rapid future increment. A total of 197 acres of plantations were treated during the year. Because of simplification of the procedure, and particularly the application of poison without frilling, average stand improvement costs for plantations and natural forests declined $3.41 to $8.62 per acre. Further economies are in sight. Nearly 40,000 trees were planted to reforest openings. About 26,000 board feet of timber was sold. This, plus other forest products yielded $1,636, of which more than one-third was reinvested in betterment of stand conditions on the areas from which the material was sold.

Use of the Forest for recreation, including the smaller more isolated Toro Negro Division, increased 10% over that of 1960. More than 288,000 recreation visits to the area were made during the year. This type of forest use is concentrated at the La Mina Recreational Area and two organization camps. The rapidly increasing use of the Forest for recreational purposes has led to plans for expansion of facilities, particularly picnic areas, for the enjoyment of the public.

The demonstration of integrated accommodation of all uses in the public interest is a guiding policy in the administration of this forest. A number of continuous uses of the Forest by individuals, companies, or agencies are authorized under special use permits. During 1961 there were currently 185 such permits in effect (in both the Luquillo and

Figure 4. Visitors at La Mina Recreational Area on a typical Sunday.

Toro Negro forests). They yielded about $9,800 in fees. These are for farming, electronic installations on the peaks, residences, rights of way, camps, and other purposes. A growing number of applications for such permits is being received.

FORESTRY COOPERATION

The Institute cooperates with local governments, industries, and individuals in a broad range of forestry activities, both in Puerto Rico and the Virgin Islands.

Outstanding among cooperative activities in Puerto Rico is the sharing of costs with the Division of Forests of the Puerto Rico Department of Agriculture for the production and distribution of planting stock for farm forest plantings in accordance with the Clarke-McNary Act and the related Cooperative Forest Management program of farm forestry assistance. Both are administered by the Division. During 1961, the Division received 1,696 requests for assistance from landowners in the area of concentrated activity, about one-third of Puerto Rico. Technical assistance was offered and 1,023,000 trees were provided for the planting of 481 acres of farm forests. Compared to 1960, this is an increase of 21 percent in number of trees and of 128 percent in number of acres planted.

Staff liaison with the Division of Forests in the administration of public forest lands continued. Specific activities included joint consideration of mutual recreational area development responsibilities, reforestation, forestry publicity, and the training of personnel

Cooperation was offered also to processors of forest products in Puerto Rico. Furniture and millwork manufacturers were shown the effectiveness of the solar drier. Small lots of imported lumber were kiln-dried to demonstrate to industry the effectiveness of this

process, little used here. Local woods were provided to a number of manufacturers for testing. The technique of treating fence posts was the subject of 10 rural demonstrations organized through the Agricultural Extension Service.

In the Virgin Islands the forestry program sponsored by the Virgin Islands Corporation continued as an Institute project. This program so far concentrated on the island of St. Croix, involves a broad range of activities, each on a small scale. Mahogany seed of the recently recognized intermediate strain was collected for a number of requests from foreign areas. A total of 12,800 mahogany trees were produced in the nursery. Of these, 7,370 were used in forest plantings, bringing the total to more than 86,000 mahoganies (and 37,500 teak) planted since the program started in 1954. Additional trees were made available to the public for other plantings, 400 were set by the program along roadsides, and 900 were shipped to the British Virgin Islands.

Forest planting in the Virgin Islands was confined to 13 acres in St. Croix, all done in strips cleared through the brush. Replanting was done in plantations with a gross area of 120 acres. Of this area, 53 acres are publicly owned. Weeding and release were done on 168 acres. The cost of all labor used on private lands was reimbursed by the landowners.

Improvement of established forests is also a part of the Virgin Islands program. During 1961, an area of 23 acres of pure mahogany forest within the Estate Thomas Experimental Forest was subjected to a crop-tree thinning to improve it as demonstration of the potentialities of good management. This treatment yielded about 2,500 fence posts.

Better forest utilization is the objective of a pilot preservative treating plant for fence posts and a small sawmill run intermittently by the Program. During 1961 some 3,500 posts were treated, of which 2,000 had been sold by the end of the year. An additional 3,000 posts are being seasoned preparatory to treatment. The sawmill cut 3,100 board feet of mahogany and thibet, all of which was sold for 50 cents per board foot or 5 cents per pound. Sales to date total about $10,000.

A small research program is under way on 25 different sites in the Virgin Islands to increase technical knowledge for application through the program. Current studies on reforestation include adaptability tests with Spanish cedar *(Cedrela mexicana* L.), primavera (*Cybistax donnell-smithii* [Rose] Seibert) and pine (*Pinus caribaea* v. *hondurensis).* Tests are also being made with seed from "birdseye" and intermediate mahogany. Growth rate comparisons are being made with recently planted trees of two species and one variety of mahogany, with fertilized teak, and with released crop trees in natural mahogany stands.

FORESTRY TRAINING

The eighth annual tropical forestry short course was held from September to early December. Five students, from Jamaica, Liberia, Nigeria, and Puerto Rico attended. The details of this course are described elsewhere in this issue. The Institute was host to four other visitors for extended periods, from Australia, Taiwan, Uganda, and Vietnam. Nine additional foreign foresters and students visited the Institute for shorter periods. Two man-years of personnel time were spent in training and showing forestry to these trainees and visitors.

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Medición del Crecimiento de los Arboles en los Bosques Tropicales[1]

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RESUMEN

Antes de empezar a llevar a cabo un estudio de crecimiento debe seleccionarse un problema específico a resolver lo mismo en regiones tropicales que en regiones templadas. Una vez que se ha seleccionado el problema, use toda la información disponible en relación al bosque o área forestal en particular y las probabilidades estadísticas en general para así reducir el número de mediciones necesarias y mejorar la precisión de las mediciones ya hechas. La realización de estas dos medidas puede reducir grandemente los gastos de, y a la vez aumentar la información utilizable a obtenerse de, los estudios de crecimiento.

A menos que se disponga de mano de obra bien barata, probablemente es mejor hacer las mediciones semanales de diámetro usando cintas de medir vernier. Las mediciones que incluyen períodos más largos pueden hacerse a satisfacción usando cintas metálicas; debe hacerse todo lo posible por eliminar cualquier posible predisposición personal o error sistemático en la medición.

La altura de árboles pequeños se puede medir con una vara graduada, pero por lo general, los árboles más altos requieren el uso de un hipsómetro. Corrientemente las condiciones en que se hace la medición afectan mucho más los resultados que el tipo de hipsómetro usado.

Cuando la naturaleza del estudio lo permite, la medición del área basimétrica puede hacerse más fácil y más rápidamente utilizando un relascopio.

SUMMARY

Before beginning a growth study in tropic or temperate regions a specific problem should be selected for solution. Once the problem is selected use all available information on the forest in particular and statistical probabilities in general to reduce the number of measurements necessary and increase the reliability of those made. These two steps can tremendously reduce the costs of and increase the useful information from growth studies.

Unless labor is very cheap, weekly diameter measurements are probably best made with vernier bands. Longer-term measurements can be made satisfactorily with a steel tape; every effort should be made to eliminate personal or systematic bias in measuring.

Height of short trees can be measured with a graduated rod, but taller trees usually require a hypsometer. Measuring conditions ordinarily affect results much more than the particular hypsometer used.

Basal area is easily and quickly measured with a relascope when the nature of the study permits.

1/ "Measurement of Tree Growth in Tropical Forests". Presentado en el Décimo Congreso de Ciencias del Pacífico, celebrado en la Universidad de Hawaii, Honolulu, Hawaii, Estados Unidos de América del 21 de agosto al 6 de septiembre del 1961, y auspiciado por la Academia Nacional de Ciencias, el Museo Bernice Pauahi Bishop y la Universidad de Hawaii.

El título —Medición del Crecimiento de los Arboles en los Bosques Tropicales— es un tanto equívoco debido a que fundamentalmente la determinación del crecimiento de los árboles y de los bosques es lo mismo en cualquier lugar. Casi todo lo que expongo a continuación puede aplicarse lo mismo en la Colombia Británica, en el Japón, o en Nueva Zelandia como en Ecuador o en las Islas Filipinas.

SELECCION DE UN PROBLEMA ESPECIFICO

El primer paso en cualquier estudio de crecimiento es seleccionar un problema específico. Hace como 20 años nuestro Instituto se interesó en el crecimiento de los bosques en los cerros húmedos calizos a lo largo de la costa norte. Como resultado, se estableció un estudio que cubría 30 acres y contenía 5000 árboles desde la base hasta la cumbre de una loma, e incluyendo exposiciones en ambas direcciones del viento o sea a sotavento y a barlovento. Cada uno de estos 5000 árboles fué medido y remedido seis veces durante un período de 15 años. En cada medición se conservaron datos individuales de cada árbol.

Hace poco decidimos comparar el crecimiento entre los árboles ubicados en la base y en la cumbre de la loma, y también los que crecían en las laderas en ambas direcciones del viento. La composición de las especies, por supuesto, variaba, y es bien sabido que el crecimiento varía según la especie, de modo que comprobamos los datos de los 5000 árboles los que incluían 74 especies para así obtener información sobre las especies que ocurrían en todos los sitios mencionados. Dichas especies resultaron ser solamente 4 incluyendo un total de 200 árboles.

Mi tesis es que esta misma información provechosa pudo haberse obtenido midiendo 200 árboles en vez de 5000. A menos que el estudio original sea planeado para solucionar un problema específico, se desperdiciará trabajo, dinero, y tiempo.

DISEÑO DE UN EXPERIMENTO PARA SOLUCIONAR EL PROBLEMA UTILIZANDO UN NUMERO MINIMO DE MEDICIONES

Una vez que se ha seleccionado el problema de crecimiento en particular, diseñe un estudio que lo solucione utilizando un número mínimo de mediciones.

Por ejemplo, cuando se desea comparar la diferencia de crecimiento entre especies distintas, es más sensible y mucho más económico la comparación entre los árboles individualmente que entre las parcelas de árboles. Evidentemente, esto mismo sucede al comparar estirpes o razas genéticas. Por lo general, éstas últimas comparaciones se hacen en plantaciones y pueden diseñarse para obtener comparaciones bien sensibles utilizando solamente unos cuantos árboles de cada clase. Así mismo, las comparaciones que se establezcan entre sitios resultan más eficientes si se basan en árboles individuales. Al comparar los sitios, y especialmente en el caso de bosques naturales, debe tenerse cuidado de eliminar o explicar el porqué de las diferencias en el efecto de las especies. Nadie establecería una comparación entre el crecimiento de una plantación de pino en un cerro y una plantación de maría en un valle para luego alegar que el primer sitio es mejor porque el pino creció más que la maría. Tratándose de los bosques naturales, aunque la diferencia en la composición de las especies tenga la misma importancia, abundan las comparaciones entre los sitios ignorando las especies.

En cambio, en el caso de los inventarios forestales de rutina para dirigir la ordenación, las diferencias entre árboles individuales tienen poca o ninguna importancia práctica. Aquí el interés se concentra en el aspecto de área; o sea, en los lotes. En tales casos, las mediciones precisas de árboles individuales y el mantenimiento de los informes sobre los mismos por lo general son superfluos.

También vale la pena indicar que el valor de un lote basado en la medición de 30 árboles por lo regular es casi tan confiable como uno basado en 100 árboles, aún cuando este se use estrictamente en relación al área. Cuando los lotes antes de ser analizados se estratifican por sitio, composición, edad, tratamiento anterior, etc. resulta más fácil, por supuesto, localizar apropiadamente los lotes pequeños. También es más probable que estos se clasifiquen correctamente ya que cada lote ocupa menos extensión y contiene menos variedad.

En pocas palabras, la naturaleza del problema bajo estudio determina el tipo y precisión de las mediciones requeridas y al determinar el número de mediciones necesarias deben considerarse las características del rodal y sus probabilidades estadísticas.

MEDICION DE LOS ARBOLES

Ahora pasemos a considerar la medición de los árboles en si, ya que según mencionamos aquí, se asume que el crecimiento equivale a la diferencia entre mediciones repetidas.

DIAMETRO-CIRCUNFERENCIA

Hasta como 10 años atrás en los estudios de crecimiento era casi universal la medición del diámetro (o circunferencia). La introducción de relascopios (o goniómetro) solo ha modificado ligeramente esta práctica. La técnica y el instrumento varían un poco de acuerdo con la frecuencia de las mediciones que se proyecten.

MEDICIONES SEMANALES. Para determinar la época en que ocurre el crecimiento, las mediciones se hacen comúnmente a intervalos de una semana o menos. En este caso la forcípula o la cinta de medir, usadas corrientemente por los selvicultores, no son lo suficientemente precisas si se emplean en la forma corriente. Para contrarrestar dicha deficiencia se han adoptado varias soluciones.

1. *Medición multinivelada.* Según lo informado por Dawkins (1956) cuando la circunferencia de un árbol se mide dentro del 0.1 de pulgada más próximo usando 10 niveles, colocando cuidadosamente la cinta sobre fajas pintadas, el promedio, expresado hasta dos puntos decimales de pulgada, resultaría lo suficientemente preciso. Además muestra un progreso consistente suficientemente sensible para tomar mediciones de crecimiento durante períodos de una semana o menos. Este método requiere una inversión alta de trabajo por árbol medido pero casi no requiere desembolsos monetarios y está prácticamente a prueba del vandalismo.

2. *Cintas vernier.* El uso de cintas vernier para medir crecimiento según ha sido sugerido por Hall (1944) se ha popularizado en los Estados Unidos. Según su uso corriente rinden lecturas exactas de circunferencia hasta de un 0.01 de pulgada. Esto es lo suficientemente preciso para anotar diariamente las fluctuaciones en la circunferencia resultantes del ciclo de la transpiración. Para preparar los anillos se requieren una plantilla, la cual es moderadamente costosa (alrededor de $50 en los Estados Unidos), una cinta de aluminio y resortes. Su instalación es rápida y fácil, y el número de lecturas por hombre-día está casi totalmente limitado por el tiempo que tome la transportación al sitio. En contraste, las cintas son bastante conspicuas en el árbol y por lo tanto propensas al vandalismo. En las regiones templadas y tratándose especialmente de árboles grandes, la expansión y contracción termal de la cinta pueden causar fluctuaciones estacionales en los valores.

3. *Compás micrométrico.* El compás micrométrico fué uno de los primeros instrumentos usados en mediciones precisas de crecimiento radial. Está colocado en una pequeña plataforma montada con tornillos grandes bien engastados en el xilema. Este instrumento muestra menos efecto termal y resulta relativamente resistente al vandalismo.

Sin embargo, aunque el robo no constituyera un problema, montar un micrómetro en cada árbol resulta muy costoso y es un poco difícil obtener resultados completamente consistentes cada vez que se coloca un instrumento en posición. Además, solo se puede medir un radio por cada montura, y los tornillos deberán engastarse bien lejos del punto de medición para que los resultados no resulten afectados por la formación de callo.

4. *Dendrógrafo.* Cuando se desean mediciones contínuas de un árbol o de pocos árboles, se usa un dendrógrafo registrador. Aunque es posible medir la circunferencia, todas las instalaciones que he visto solo miden el radio. Su precio elevado y la susceptibilidad al robo y al vandalismo limitan considerablemente el posible uso de este instrumento.

MEDICIONES ANUALES. Para determinar el crecimiento de diámetro por períodos de un año o más, es posible obtener resultados consistentes mediante el uso cuidadoso de una cinta metálica. Nosotros usamos una cinta de acero colocada sobre una línea pintada y leemos el diámetro hasta un décimo de pulgada completo. Aunque la medición de un anillo pintado completamente alrededor del árbol, teóricamente es más consistente que cuando la pintura cubre solamente de una octava a una cuarta parte de la circunferencia, bajo nuestras condiciones de trabajo no nos ha sido posible demostrar alguna ventaja.

Por esta razón hemos descontinuado el uso de los anillos completos. También medimos hasta las unidades completas en vez de hasta la unidad más aproximada para así reducir la predisposición en favor de especies preferidas; por esta misma razón no permitimos que el medidor sepa el resultado de la medición anterior antes de remedir. Si la segunda medición resulta incompatible con la primera solamente es instruído para que revise su remedición. Cuando no tomamos estas precauciones hemos encontrado que árboles aparentemente vigorosos y de especies preferidas disminuyen repentinamente en crecimiento casi siempre después del período inicial de medición.

Vale la pena mencionar que en la mayoría de las regiones tropicales el crecimiento varía por temporadas, por lo cual la época de medición debe planearse de acuerdo.

MEDICIONES PERIODICAS. La medición del crecimiento de diámetro en períodos de cinco años o más se obtiene con facilidad usando una cinta de medir o hasta unas forcípulas y las medidas resultan bastante consistentes. Si los estudios se planean con suficiente previsión que permita medir los árboles al principio y al final de un período de crecimiento, la falta de los anillos anuales de crecimiento, los que son fáciles de contar, resulta de poca importancia.

Sin embargo, si la necesidad es bien urgente, se puede recurrir a contar los anillos de muchos árboles tropicales por lo menos en regiones que tienen fluctuaciones en la precipitación. En Puerto Rico, aún en lugares donde la precipitación excede las 150 pulgadas al año, algunas especies forman anillos anuales de crecimiento relativamente bien definidos. Cuando se requieren cálculos casi perfectos, el uso de cilindros de madera de 8-10 milímetros, obtenidos con el barreno de Pressler y los consiguientes colorantes, secciones transversales microscópicas y los registros pluviométricos son necesarios.

MEDICIONES DE ALTURA

Las técnicas e instrumentos de medir la altura varían principalmente con la altura de los árboles a medirse.

ARBOLES PEQUEÑOS. Los árboles de menos de 12-15 pies de altura pueden medirse fácilmente con varillas de una sola pieza o de secciones. Por lo general, las mediciones precisas de árboles de más de 6 pies de altura deben hacerse con cuidado para evitar errores de paralaje.

ARBOLES MEDIANOS. Los árboles de altura mediana pueden medirse con varias clases de hipsómetros o varas de extensión.

Cuando hay que medir muchos árboles aglomerados y las condiciones permiten llevarla, una vara de extensión es tan exacta y su uso es más rápido que en el caso de los hipsómetros. Las lecturas debe hacerlas siempre un observador a alguna distancia de la base del árbol objeto de la medición.

Hay una variedad de hipsómetros lo bastante precisos para casi todos los propósitos. Probablemente, el Abney, que incorpora un nivel de burbuja, es el más corriente. Sin embargo, varios de los últimos hipsómetros de péndulo son más rápidos y fáciles de leer. como también menos costosos. El hipsómetro de Haga y Blume-Leiss tienen varias escalas siempre disponibles, el Suunto es el hipsómetro de lectura más rápida pero solo tiene escalas de porcentaje y de grado.

Los telémetros incorporados en algunos hipsómetros son muy convenientes para determinar la distancia horizontal hasta el árbol, sin embargo, su precisión deberá confirmarse antes de considerarlos confiables.

ARBOLES ALTOS. La altura de árboles de más de 50 pies de alto se determina casi universalmente por medio de hipsómetros. Se obtiene más precisión usando cualquiera de los modelos corrientes que la que un forestal pueda lograr bajo condiciones normales en el bosque, especialmente en la medición de árboles de copa redonda. En dichas mediciones se puede mejorar la precisión midiendo desde el punto más lejano posible de la base del árbol. La consistencia de las mediciones se mejora marcando el punto desde donde se hacen las observaciones de modo que las subsiguientes mediciones puedan hacerse desde el mismo sitio.

Casi todos los errores cometidos en la determinación de la altura de los árboles que tienen el extremo y la base definidas y bien visibles se deben a mediciones inexactas de la distancia entre el observador y el árbol o al uso incorrecto del hipsómetro. Algunas veces, especialmente cuando se usa un hipsómetro de Haga, se hacen las observaciones antes de que el péndulo se coloque en su posición final. Ocasionalmente se exige repetir las mediciones para verificar el modo de usarlo.

AREA BASIMETRICA POR ACRE

Algunas veces el área basimétrica por acre (o cualquier otra unidad de área) es la unidad de crecimiento que se toma en consideración. Esta es una unidad especialmente común que sirve de guía en el manejo extensivo de áreas extensas. Cuando una parcela contiene más de como 25 árboles, registramos el número de árboles en cada clase o categoría que incluye 1 pulgada de diámetro y lo convertimos directamente en términos de área basimétrica; hemos hallado que esta solución es tan útil como la que se obtiene al medir árboles individualmente y convertir dichas medidas en términos de área basimétrica. El uso de pocas categorías amplias en vez de muchas categorías limitadas permite el uso de cuadrillas de conteo acumulativas ahorrando aún más tiempo.

Cuando no se interesa información sobre la estructura del rodal y la maleza no es excesiva, el área basimétrica del lote puede medirse usando algún tipo de relascopio; nosotros preferimos la prisma de cuña por la conveniencia de su uso y por ser extremadamente fácil de portar. Se puede obtener virtualmente cualquier grado de seguridad o exactitud si se selecciona el calibrador apropiado del relascopio; un relascopio de factor 10 casi equivale a parcelas de un quinto de acre en rodales con un diámetro medio de un pie y es superior en rodales de diámetro superior. Los relascopios son mucho más rápidos que cualquier otro medio de *medir* el área basimétrica de un rodal.

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The Status and Development of the Nicaraguan Pine Savannas

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SUMMARY

The pine region of the coastal plain of Nicaragua is described, its ecology and history as well as current conditions. Studies indicate pine forests are a fire disclimax which reproduces abundantly with fire protection following repeated burnings. Proposed fire control measures are described.

RESUMEN

Se hace una descripción de la región cubierta de pinos en los llanos del litoral de Nicaragua, de su ecología e historia, así como también de las condiciones actuales. Los estudios hechos indican que cuando los bosques de pino se protegen de los incendios después de quemas repetidas, se reproducen con abundancia. Se discuten medidas propuestas para controlar los incendios.

During the period November 1956 to April 1961 the author was engaged in carrying out a series of land-use surveys in Nicaragua under the Expanded Technical Assistance Programme of the Food and Agriculture Organization of the United Nations. The results of these surveys have since been published (Taylor 1959, 1961). The first survey covered an extensive area of pine savannas in the North Atlantic Coast and as a result of subsequent recommendations a reforestation programme was commenced. The basis for this programme and its initial development will be described in this paper.

DESCRIPTION OF THE AREA

The Nicaraguan pine savannas are a continuation of the Mosquito Coast savannas and mostly lie between the Honduran border and the Rio Grande de Matagalpa, although a few scattered stands extend south almost to Bluefields at latitude 12°10'N. They extend inland for up to 70 miles, but except for the small area near Puerto Cabezas, they are separated from the Atlantic coast by a wide band of swamp, and swamp also occurs scattered throughout the zone.

The whole area has a wet tropical climate with no part receiving less than 100 inches of average annual rainfall nor having more than 3 dry months. Despite this wet climate almost all the savanna is burnt annually. In dry years estimates of the amount burnt exceed 99%. The topography is flat to rolling with the highest hill having less than 600 feet elevation. Almost all the savanna occurs on an extensive area of marine sediments of Pliocene and Pleistocene age. This area was at one stage a piedmont plain but has been subsequently uplifted, and a new erosion cycle is well developed. The higher hills remaining are flat topped with a concretionary ironstone cap. Elsewhere the soils are a characteristic red-yellow latosol on the better drained areas, and hydromorphic soils with very high organic contents on low-lying sites. The rainforest adjacent to the savannas is typically found on basic Tertiary volcanics

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with brown latosols, or on alluvium. The correlation between the vegetation and the geological formations is striking; but it is not absolute, as small stands of pine savanna occur on Tertiary volcanics and some rain-forest stands on the marine sediments.

The population actually living within the savannas proper is negligible; but there are approximately 20,000 people in scattered villages in coastal areas, or in fringing forest along the main rivers.

The accessibility of the area between the Rio Huahua and Rio Coco is very good. There is a port for ocean-going ships at Puerto Cabezas, linked with the Rio Coco by a good quality gravel highway. Leading off this highway is a network of logging roads which give access to the whole area. Road building in this well drained part of the savanna has been greatly facilitated by the abundant supplies of gravel throughout the marine sediments. This has permitted rapid and relatively cheap construction of year-round roads. The access to the area south of the Rio Huahua is far more difficult. Extensive areas of swamp preclude a road link and, although there are small systems of logging roads on the better drained savannas, these are linked to Puerto Cabezas by barge traffic only.

PAST EXPLOITATION

The pine savannas have had a long history of exploitation for naval stores on a minor scale, but extensive exploitation for timber has only occurred since 1930, with the average annual production from 1950 to 1960 exceeding 20,000,000 board feet. However the result of this exploitation has been a very serious depletion of reserves. By the beginning of 1961 only small stands of commercial size remained in the accessible area north of the Rio Huahua, with the result that production has been greatly reduced. Although extensive reserves still remain south of the Rio Huahua, particularly in the upper reaches of the Rios Bambara and Cucalaya, there is little prospect of any significant exploitation in the near future because of access problems This reduction of pine production is particularly serious because the timber industry has been the only significant cash income for the people of the region for the last twenty years. Fortunately, the recent buoyant market for pine resin and the extremely high quality of the virgin pine stumps in the savannas combine to make a wood naval stores plant commercially attractive, and it is planned to have a plant in production in 1962 to assist in the economic recovery of the region.

The logging methods adopted have taken advantage of the very good access of the well drained savanna, with an intricate system of minor logging roads leading off the main highways. The trees are cut by 2-man crosscut saws, bunched by tractors, crane loaded onto 10-ton trucks and carted a maximum distance of 5 miles to the main highways. The logs are then reloaded onto 25-ton trucks for transport to the mills for distances up to 50 miles. From the mills the rough sawn timber is then transported, also by 25-ton trucks, to the port for planing and export. The bulk of production is then exported for building construction in the Caribbean islands, but up to 20% of the highest quality is exported to Europe mostly as dimension mine timbers.

BOTANICAL DESCRIPTION OF THE SAVANNA

The pine savannas have been described at some length in Taylor (no date). In brief, the typical community consists of an open tall tree layer and a dense ground layer, but an open small tree layer or a bush layer may be present occasionally. The tall tree layer consists entirely of one species *Pinus caribaea* (var. *hondurensis*) typically from 70 to 100 feet in height. The pines are normally widely scattered, but the density is extremely variable and occasional stands have an almost

continuous canopy. The small tree layer consists of *Curatella americana* and *Byrsonima crassifolia*, and the bush layer of *B. crassifolia* and many species of *Melastomaceae* and *Myrtaceae*. The ground layer is of mixed composition with many grasses and sedges with the local composition depending partly on site conditions but more particularly on the intensity of past burning.

An area of approximately 10,000 acres of "bush" pine occurs near Miguel-began. This community consists of an open layer of pine trees, 120 feet high, above a continuous layer of mixed hardwood trees at 70 feet, but with no smaller pines or pine seedlings present. The "bush" pine apparently represents an invasion of pine savanna by hardwoods. Similar, but far smaller, occurrences of "bush" pine are found scattered around the edges of the savanna.

A few very small areas of the typical savanna have been protected from fire but mostly only for short periods. However, around the Mission Hospital at Bilwaskama fire has been effectively excluded from 15 acres since 1944. As a result, the typical savanna has been replaced by a dense growth of young, even aged, pines which have formed a continuous canopy. Below the pine layer there is a continuous layer of hardwood shrubs without any young pines. Areas protected from fire for shorter periods show a similar dense pine regrowth, but without a well developed hardwood layer.

BASIS FOR THE REFORESTATION PROGRAMME

As a result of the information collected in the land survey, it was concluded that the savanna was a fire-caused disclimax and that the true climax was in fact a rain forest. Further, that with fire protection, a succession would commence from savanna to rainforest, and that the first stage in the succession would be a dense pine forest. The reasons for this conclusion are that climatically the area is well suited to rainforest, for no part of the zone has an average of more than three dry months per year and moreover the savannas are not only surrounded by rainforest but are crossed by strips of rainforest fringing major rivers. It should be emphasized that this rainforest is not a seasonal rainforest but is the evergreen rainforest of tropical lowlands under the exacting definition of Beard (1944). Further, although the red-yellow latosols are inherently very infertile, several stands of rainforest were observed on these soils in the zone. Moreover the fertility is not so low as the white sands of the Guianas which support tall rainforest. Davis and Richards (1933). The survey's conclusions are of course strongly supported by the evidence of the observed plant succession following protection from fire.

Accordingly, a recommendation was made that a fire protection project should commence ultimately to include all the accessible areas of well-drained savanna between the Rio Huahua and Rio Coco. The suitable area amounts to 800,000 acres already linked by highway to an ocean port. This whole zone was used only for rough grazing at a stocking rate of one beast to several thousand acres so that apart from its use for reforestation the area could be considered practically valueless.

To support this recommendation yield studies were made in the latter part of 1958. The actual annual yield per acre of the savanna was found to be negligible, for not only were the trees very widely spaced but the annual burning was found to have a strong depressing effect on the growth rate of even the taller trees. In the taller trees the ring count averaged 8 to 10 per inch indicating 4 to 5 years for one inch diameter increase. However, the examination of individual pine trees growing near the boundaries of the savanna, but surrounded by low hardwood growth, showed that at a time roughly corresponding to the age of the surrounding hardwoods and thus of an accidental cessation of burning, the growth had suddenly and

markedly increased. In most cases, despite competition from the hardwoods, the diameter increase of the pines was doubled. Accordingly, no attempt was made to estimate yields under the normal conditions of annual burning, and attention was concentrated on estimating yields from the areas which had received fire protection.

In the protected area at Bilwaskama yield estimates were made on six plots. These varied between 87 and 102 cubic feet per acre, per year, of total wood production and gave a mean value of 90 cubic feet. Unfortunately, no other fire protected stand was of sufficient age to give a comparable yield estimate for different site conditions. After considering that Bilwaskama yields should be a little higher than average, and making allowances for fire losses, roads and swamps, a crude estimate was made of an expected yield of 58 cubic feet per acre, per year ($4m^3$ per hectare per year) over the whole 800,000 acres. Such a yield is very low when compared to normal yields of pine plantations and is due partly to the use of natural regeneration instead of carefully spaced plantings; but more particularly, the low yield is due to the infertile nature of the soils. Nevertheless, a yield of even one-third this figure would still have been favourable for the project, for the main cost is that of fire prevention with naturally no planting cost and a land value solely dependent on its value for reforestation.

The estimated yields assumed that the amount of regeneration over the whole area would roughly correspond to that at Bilwaskama. Numerous counts of the density of young seedlings were made, to check this assumption. It was found that the density was extremely variable and also that the figures obtained depended on the size and shape of the sample plots.

A plot size of 10 m. by 5 m. was finally chosen and very numerous observations scattered over the project area gave the following indications of density:

Seedlings per Acre	Percentage of Area
0 — 200	10
200 — 400	15
400 — 800	15
800 — 1600	20
1600 — 4000	30
4000 +	10

These figures indicated that the problem of understocking would be relatively minor and on the contrary measures might need to be taken to reduce many of the stands. Subsequent investigations showed that there was a 10% mortality after one year of fire protection but, nevertheless, a net increase of 12% in seedling numbers due to the germination of a second crop.

FIRE CONTROL PROGRAMME

Following on the favourable indications obtained by the preliminary investigations an experimental fire control programme with a very limited budget was set up in January 1959 by the Nicaraguan Instituto de Fomento Nacional. This at first covered only 25,000 acres but as the low density of population made fire control relatively simple, the area was expanded in February 1959 to 60,000 acres and again in early March to 120,000 acres. In 1960 the scope of the project was expanded and experiments started to determine the most economic methods of fire control, at the same time the area was increased to 200,000 acres. In 1961 a fully equipped programme commenced with the intention of expanding the area 60,000 acres a year until the full 800,000 acres is under protection.

Despite the experimental nature of the first two years' programme and the restricted budget, fire losses were slightly less than 2% annually of the area protected.

The fire control programme has many aspects; most important is an education

campaign, for all fires encountered were certainly man-made. This campaign emphasizes the fact that when in production the reforestation project will solve the great need for more employment in the region. Coupled with this campaign is a regular motor cycle patrol which has been found to be a cheap preventive measure. The actual control system is based on a grid of radio equipped wooden observation towers as control points, every 70,000 acres, high-speed roads and radio equipped control trucks. The control trucks are fast four-wheel drive vehicles carrying high-pressure fog water pumps and a small team of men with hand tools. When all planned roads are completed these control units will reach the most distant point in a maximum of one hour after the fire commences, but even in 1960 the maximum delay was only an hour and a half. The use of fire breaks was discontinued due to high cost of annual reclearing, but as the fire danger rises with accumulation of unburnt litter this matter will need to be re-examined. The use of tractors for fire control is not regarded as at present economic. The pumps have proved effective at a far lower initial cost and although they require a supporting team of men, these can be fully occupied in necessary road building and general construction work when not engaged in actual fire fighting.

INVESTIGATION PROGRAMME

As the Nicaraguan reforestation scheme is being undertaken under somewhat unusual conditions, an extensive investigation programme has been initiated to determine the most economic methods. The first aspect of this programme has been laying of 200 permanent sample plots to be examined yearly with the height and location of every seedling being recorded. At a later date the diameter of each tree will also be recorded. These plots are arranged to give a representative sample of site conditions but are widely scattered. The bulk of the plots are in areas which had been burnt in 1958, but others are located in the very small areas which had received up to five years accidental fire protection. When sufficient data has been collected from these plots it will be possible to predict yields and optimum density for the various site conditions, as a basis for future exploitation and for possible control of the density of stocking.

A further series of experiments is being carried out with controlled burning during the wet season. This aims at determining whether some of the areas with low stocking have been caused by fires soon after germination of the seedlings in July. This appears likely for such sites would probably not be burnt the next dry season, March and April, and by the next July competition from grass would be great with resultant poor establishment of seedlings. If this is found to be true the areas concerned could be reburnt early in the dry season and good crop of seedlings would then be established.

Further experiments on wet season burning are being made to observe seedling mortality from burning at different ages and heights, so that controlled burning to reduce the fire hazard can be introduced as soon as possible. Two-year old seedlings burnt during the wet season showed only a 10% survival rate but within one or two more years this should rise sufficiently to be acceptable in the more heavily stocked areas. Dry season fires at this age would still result in an almost 100% mortality.

Other investigations are being made on fire danger prediction as well as continuous experiments to find the cheapest methods of observation, communications and control under local conditions.

REGIONAL DEVELOPMENT

Although the reforestation programme is now firmly established, its effects are long range; but the slowing down pine exploitation is already having a serious effect on the region's economy. Accordingly, the Nicaraguan

Government, through the Instituto de Fomento Nacional, has decided to implement other recommendations made by the land survey in an integrated development programme. This programme envisages developing exports of bananas, cocoa, rice, horticultural crops, beef and an expansion of the hardwood trade, as well as exploitation of further minor forest products. Each of these aspects of this programme is aimed at utilising various favourable combinations of land conditions in different parts of the region.

Already preliminary investigations in many aspects have commenced but very considerable studies are still needed before the programme can be translated into a commercial reality.

To facilitate the programme the Nicaraguan Government has recently applied for assistance to the Special Fund of the United Nations, with the Government and the Fund sharing the cost, U.S. $1,200,000 over the next four and a half years. While both the reforestation and the regional development schemes are at an early stage, they illustrate the value of a land survey in giving details of the land potential, especially in such little known regions.

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Report on 1961 Tropical Forestry Short Course

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SUMMARY

Five participants took part in the Tropical Forestry Short Course which took place September 4 to December 2, 1961. The purpose of the course was to introduce to these men the principles and techniques of tropical forestry. This was done through lectures, films, field trips, and student reports.

RESUMEN

Cinco funcionarios participaron en el Curso de Entrenamiento en Dasonomía Tropical celebrado en el Instituto de Dasonomía Tropical durante septiembre 4 a diciembre 2, 1961. El objeto principal del curso fué demostrar a estos participantes los principios y técnicas de la dasonomía tropical por medio de conferencias, viajes de observación al campo, películas, e informes preparados por los participantes.

In Latin America, Africa, and Asia development of natural resources is being slowed by a lack of trained personnel.

This is especially true of forestry. One of the participants of this year's course manages more than a thousand square miles of African forest. For this man, modern forestry techniques such as angle gauge cruising are not a convenience but a necessity.

Europe and America are in a position to help these nations by introducing them to time-saving techniques and accurate, reliable methods, and by explaining the forest policies which have evolved through years of experience.

The Tropical Forestry Short Course is a small part of this effort. Sponsored by the Agency for International Development (AID), this course is held each year in Spanish and English with participants from Latin America, Africa, and Asia. The course is conducted by the U.S. Forest Service at the Institute of Tropical Forestry, Rio Piedras, Puerto Rico and lasts 3 months, September through November. It is designed primarily for technicians in junior positions. The participants attend lectures, participate in field exercises, and take field trips which illustrate both the basic principles and most modern techniques of tropical forestry.

PARTICIPANTS

In 1961 all the participants spoke one language, English. This, and their relatively small number, made it possible to intensify the training, to tailor the material closely to the needs of the individual, and to enjoy close personal contacts. The course ran from September 4th to December 2nd. Five participants took part.

Liberia: A. S. Kamara, a graduate of the University of Liberia. Mr. Kamara has the position of Forest Supervisor working with the Sales Division. Prior to this visit to the United States, he was directly engaged in supervising the operation of the Tropical Trading Company. This included scaling, advising and checking on forest operations, reporting taxation when due, and describing unknown species.

Nigeria: R. I. Nwokolo, a graduate of the School of Forestry in Nigeria. A Senior Forest Assistant, Mr. Nwokolo's duties included the management of a Territorial Unit,

Figure 1. Participants in 1961 Tropical Forestry Short Course. Left to right: E. U. Bryan, R. I. Nwokolo, A. S. Kamara and H. A. King. Not shown D. Ruiz González.

supervision of a silvicultural program, protection of the Forest Estate, and general administration.

Jamaica: E. U. Bryan, Forester Grade I with the Forestry Department. Since 1956 Mr. Bryan has been Assistant District Supervisor in charge of transport, stores, seeds and plant distribution, and checking technical returns from the divisions.

Jamaica: H. A. King, Assistant Supervisor with the Forestry Department. In Jamaica, Mr. King supervises foresters in general administration and maintenance.

United States. D. Ruiz-González, a graduate of the University of Puerto Rico College of Agriculture. Mr. Ruiz works for the Puerto Rico Division of Forests in the field of Cooperative Forest Management with private land owners.

The Office of Technical Cooperation of Puerto Rican Department of State took charge of the personal needs of the participants during their stay. Special thanks are due Mr. Alzamora of this organization who, as the liaison man with the Institute of Tropical Forestry, was instrumental in providing the services of the OTC.

The participants lived with private families within walking distance of the Institute. A large part of the success of the training is undoubtedly due to the hospitality of the families who acted as hosts.

COURSE PROGRAM

Instruction was carried out by members of the U. S. Forest Service attached to the Institute of Tropical Forestry with the assistance of the lecturers and organizations listed in the final section of this report.

Whenever possible, lectures were followed by a supporting field trip. The participants wrote reports covering every trip, complete with names and addresses of the people involved.

The instructors used practical exercises to insure that new techniques were understood. Every effort was made to see that these techniques were understood to a degree that they could be passed on by the participant in his country; if not in theory, then in clear concise rules for practice.

An extremely important part of the course was the series of roundtables, opportunities for the students to present the particular problems and conditions in their own countries. These discussions showed each student that his country was not alone in trying to solve major problems, and that in fact, the problems were similar in many cases. In giving these talks, the student benefited by studying his own country and its problems.

The course program and time allowed for each part were as follows:

DESCRIPTION OF PUERTO RICO (2 DAYS)

Puerto Rico is an ideal location for training people. It is not yet so developed that the original problems are completely solved, yet progress is obvious. Besides the various talks by local experts on history, geography, industry, and forestry, the visit made to a tractor station with Mr. Muller of the Commonwealth Education Department, was the most popular event of these two days. Here was the beginning of an attempt to bring mechanization to the farms, a school where young farmers could learn to operate and maintain mechanized equipment. Although our visitors were foresters, they recognized a familiar problem with its answer here.

ROUNDTABLE NO. 1, DESCRIPTION OF PARTICIPANTS' COUNTRIES (1 DAY)

Each participant described general conditions and developments in his own country.

GENERAL FORESTRY (1 DAY)

The Director of the Institute, Dr. Wadsworth, outlined the broad role of forestry in

tropical countries, and its relationships to other sciences and resources. A talk by Mr. Seda, Director of the Puerto Rico Division of Forests described local conditions. A field trip to the center of the island illustrated field conditions under forests and farming, and provided an opportunity to discuss problems and solutions.

DENDROLOGY (3 DAYS)

Tropical forests are complicated. One of the difficulties is that there are many species, some known and some unknown. Puerto Rico, for instance, has more than 500 native tree species. In order that the participants know how to attack this problem efficiently in their own countries, Mr. Marrero, a Research Forester of more than 25 years experience in the Tropics, illustrated how to collect and classify plant specimens. Each student received a full set of notes which were explained in detail, and made a key to 25 unknown specimens. With this information and experience, they are now able to organize for instance, a short training course on tree identification for their own personnel.

ARTIFICIAL REGENERATION (4 DAYS)

One of the first and most obvious steps in the development of efficient forest production is the planting of bare areas or of recently cut-over areas. Because of the importance of this field, a relatively large amount of time was spent in lectures and field trips. Dr. Briscoe, Head of the Forest Management Research Section of the Institute, reviewed the purposes, problems, and methods of artificial regeneration. Special emphasis was placed on nursery production. A visit to the Commonwealth Forest Nursery was made during the second day. In order that planting conditions could be seen at different sites, two more days were spent with Dr. Briscoe and Mr. Marrero traveling to plantations throughout the island. The factors unique to each site were discussed.

ECOLOGY (2 DAYS)

Success in plantations and silvicultural operations is ultimately dependent on an intimate knowledge of ecology, the relationship of the tree to its surroundings. With the help of ecology, one can explain many of the features of the tropical forest and avoid costly mistakes in plantation failures. Two days will not make a forester an ecologist, but Dr. Wadsworth did make clear the importance of ecology as a tool in understanding the forest. With his twenty years of experience, he was able to illustrate with practical examples. The Luquillo Experimental Forest provided a chance to apply lecture material to forest conditions.

The use of recently published plantation reports to aid forestry departments in choosing new tree species for introduction was also presented during this phase of the course.

ENGINEERING (5 DAYS)

One of the basic skills foresters need is that of using a compass and tape and being able to draw a usable map of a forest area. During these five days, training was given in the use of basic surveying instruments. Two methods of survey were practiced and appropriate maps were drawn. This part of the course was under the direction of Mr. Sposta, in charge of the Experimental Forest.

AERIAL PHOTO INTERPRETATION (5 DAYS)

Because foresters deal with large areas, aerial photo interpretation as an aid to extensive management has been included in the course. With the help of a training kit prepared by the U. S. Forest Service, actual problems in determining areas, distances, scale, forest types, and stand classes were worked out. The participants keep the kits and are provided with additional information so they may pass on what they learn. In charge of the course was Mr. Ortiz of the Puerto Rico Division of Forests.

FOREST INVENTORY (9 DAYS)

Any intelligent activity in forests is based on a knowledge of volumes and ages of the stands. For this reason, an important place was given the study and practice of forest inventory. Under the direction of Drs. Briscoe and Barres, the first four days were used making clear the theory and statistical methods necessary for a forest inventory. Several problems were worked out in class, then two types of cruise were carried out in the Luquillo Experimental Forest. Both the traditional method of measuring plot perimeter and diameters with a tape, as well as the newer method of angle gauge cruising were practiced. The students compiled field data of both cruises and submitted a report.

SILVICULTURE (6 DAYS)

Two days of lectures by Drs. Wadsworth, Briscoe and Barres were devoted to this topic. In addition four days of field trips provided practical examples of the thinning techniques in plantations, mixed tropical forest, and in mangrove forest.

UTILIZATION (5 DAYS)

Mr. Maldonado, of the Institute and Dr. Peck of the Forest Products Laboratory of the U. S. Forest Service gave lectures on harvesting, sawmilling, wood preserving, and other aspects on forest utilization. Field trips were taken to a wood preserving plant, a furniture factory, a paper mill, and a Fiberdyne plant.

PROTECTION (1 DAY)

Because of time limitations, only one day was devoted to discussion of protecting forests from disease, insects, and fire. Mr. Sposta lectured on this subject.

MANAGEMENT (2 DAYS)

Dr. Wadsworth discussed past trends in forest management and indicated future trends on the basis of his experience. Discussions of individual problems were held as the participants brought them up.

RESEARCH (1 DAY)

Drs. Wadsworth and Briscoe indicated the requirements of a good research program so the participants would understand better the problems and possibilities of research programs in their own areas.

PUBLIC FORESTRY (1 DAY)

During this day, participants discussed with Mr. Sposta the organization of the U.S. Forest Service, and compared it with their own.

PRIVATE FORESTRY (2 DAYS)

Each government agency dealing with forestry was invited to send a representative to form a panel which discussed helping private land owners practice forestry. The active participation of all was an indication of how interesting and necessary this topic is. The members of the panel are listed under Participating Agencies.

The second day, the group went out with Mr. Quiles of the Puerto Rico Division of Forests to visit forest plantings established under cooperative agreements between private owners and the government.

ROUNDTABLE No. 3, POLICY, LEGISLATION AND SPECIAL PROBLEMS (1 DAY)

During this part of the course, forest law and policy were discussed with the entire staff of the Institute. Here, too, was a chance to bring up any special problems which the individual countries faced.

All parts of the course were supported wherever possible with films and slides of the Forest Service. The library of the Institute was open throughout the course for use by the participants.

PARTICIPATING AGENCIES

FEDERAL AGENCIES AND REPRESENTATIVES PARTICIPATING IN TRAINING

Institute of Tropical Forestry, Forest Service, U. S. Department of Agriculture - The Staff.

Agricultural Stabilization and Conservation Service, U. S. Department of Agriculture - Mr. Montoya.

Agricultural Experiment Station, U. S Department of Agriculture — Mr. Warmke.

Soil Conservation Service, U. S. Department of Agriculture - Mr. Gracia.

PUERTO RICAN AGENCIES AND REPRESENTATIVES PARTICIPATING IN TRAINING

Office of Technical Cooperation, Department of State - Mr. Colom, Mr. Alzamora, and Mr. Pérez.

Division of Forests, Fisheries and Wildlife, Department of Agriculture - Mr. Seda, Mr. Ortiz, and Mr. Quiles.

Agricultural Extension Service, Department of Agriculture - Mr. Angleró.

Division of Education, Department of Education - Mr. Muller.

Puerto Rican Industrial Development Co. - Mr. Gotay.

PRIVATE FIRMS VISITED

El Guacio Crafts, San Sebastián, P. R.

Fiberdyne Corporation, Ponce, P. R.

Furniture Factory of Puerto Rico, Yauco, P. R.

Puerto Rican International Paper Co. Ltd., Arecibo, P. R.

Wood Treating Industries Inc., Hato Rey, P. R.

Modificación del Programa de Enseñanza

El Instituto Interamericano de Ciencias Agrícolas ha anunciado una modificación de su programa de enseñanza a nivel postgraduado. Desde el 1 de octubre de 1962, cuando se inicia el nuevo año escolar, habrá dos programas para los candidatos que aspiran a optar al título de *Magister Agriculturae* en nuestro Departamento de Dasonomía.

(1) El programa para ingenieros forestales con un mínimo de 12 meses de duración donde el candidato deberá tomar ciertos cursos avanzados en la materia forestal o cursos que se estimen puedan llenar lagunas o reforzar sus conocimientos básicos.

(2) El programa para técnicos con títulos de Ingeniero-Agrónomo o su equivalente cuya residencia será por un período de 24 meses y que incluirá una serie de cursos forestales básicos en su primer año y un programa de cursos más avanzados en su segundo año.

En ambos programas se dará especial énfasis a las prácticas, trabajos de revisión bibliográfica y la presentación de una tesis sobre un tema original de investigación.

Con esta reestructuración del programa de adiestramiento, se espera que el ingeniero forestal tenga la posibilidad de profundizar en los temas de especial interés mientras que su trabajo de tesis le proporcionará el adiestramiento necesario para resolver en forma científica un problema determinado.

Para el Ingeniero Agrónomo o su equivalente, se pretende complementar sus conocimientos básicos adquiridos en el curso de su carrera profesional, con aquellas materias netamente forestales que le permitirán desempeñar satisfactoriamente su profesión a la vez que el programa de estudios de su segundo año le permitirá tomar cursos forestales avanzados y dedicarse de lleno a la tesis. Su proyecto de tesis le preparará asímismo como investigador y le capacitará para resolver los problemas de su profesión con los enfoques científicos necesarios.

Con este paso, el Departamento de Dasonomía intenta reflejar el cambio contínuo que se está operando en América Latina, amoldando mejor sus programas a las necesidades de los países americanos. Con mucho gusto podemos enviarle informaciones adicionales.

DEPARTAMENTO DE DASONOMIA

I Cursos básicos ofrecidos por el Departamento de Dasonomía de interés para los diferentes Departamentos del Centro de Turrialba.

1er. Trimestre:
- Dendrología
- Fotogrametría
- Meteorología y climatología

2do. Trimestre:
- Ecología
- Planeamiento del uso de la tierra

Además, para los estudiantes del Departamento de Dasonomía, se considerarán como básicos, varios de los cursos ofrecidos por otros Departamentos, tales como: suelos (1 y 2) estadística, diseño experimental, genética, anatomía y morfología, patología, entomología, fisiología vegetal (varios cursos), redacción técnica, uso de biblioteca e inglés.

II Cursos básicos ofrecidos por el Departamento de Dasonomía, de interés sólo para estudiantes forestales.

1er. Trimestre:
- Dasometría
- Protección forestal
- Tecnología forestal

2do. Trimestre:
- Ordenación forestal
- Silvicultura

3er. Trimestre:
- Política y administración forestal

Ingeniería forestal
Utilización de productos forestales e industrias forestales
Prácticas de silvicultura y ordenación

4to. Trimestre:

Viaje de prácticas a Honduras, Guatemala y México

III Cursos forestales avanzados ofrecidos por el Departamento de Dasonomía

1. Problemas de dendrología
2. Problemas de ecología
3. Problemas de ordenación
4. Problemas de evolución y genética forestal
5. Fotogrametría aplicada a inventarios forestales
6. Problemas de planeamiento del uso de la tierra
7. Problemas de silvicultura tropical

Los estudiantes forestales también podrán tomar otros cursos avanzados ofrecidos por otros Departamentos y de interés para su programa de especialización. Los principales son:

Fisiología vegetal (ciertos cursos)
Citología, Citogenética y Fitomejoramiento
Botánica de cultivos tropicales
Isosopos radioactivos
Microtecnia y microfotografía
Fundamentos del trabajo de extensión
Metodología de extensión, etc.

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Forests and Dominant Legumes of the Amatuk Region, British Guiana

by

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SUMMARY

A description of the forest occurring on two of the soil types found in the Amatuk region of British Guiana is given. Both white sand and ironstone hills are characterized by the dominance of a few abundantly nodulated legume trees, most of which occur on both soils. The overwhelming success of these trees here does not seem to be explained fully by the probable nitrogen deficiency of the soils, and other factors tentatively suggested are relatively good illumination at the lower levels in the forest and good soil aeration.

Data is given about various biological features of the forest, especially root morphology and those aspects which give some clues to the dynamic processes operating. A survey of dead compared with living trees indicated that the percentage of wood dead was lower in dry than in moist forest on white sand, and perhaps lower still on ironstone.

The four most important legumes (**Eperua falcata, Dicymbe altosoni, D. corymbosa, Dimorphandra davisii**) are used as examples for many of the phenomena described. The last in particular shows many interesting features. Most of its inflorescences fell off at the time of flowering, and relatively few seedlings develop; none of these grow beyond the sapling stages in undisturbed forest, but sufficient disturbance is sometimes caused by the fall of its own trunk to permit the growth of its saplings. In addition such fallen trunks frequently develop a row of new trees by vegetative means, with living wood connecting the bases of the new trees.

D. **davisii** shows at least some tolerance of fire damage, and in parts of an area burnt in 1926, this is almost the only species regenerating, although dead standing trunks of other species are still visible. It is suggested that this and other species of **Dimorphandra** may be favoured by burning, and a warning is given about the long-term effects of fires in these forests.

RESUMEN

Se hace una descripción de los bosques que ocurren en dos de los tipos de suelo en la región del Amatuk en la Guayana Británica. Tanto las lomas de arena blanca como las lateríticas ferruginosas se caracterizan por el dominio de algunos árboles leguminosos que poseen nódulos en abundancia, la mayor parte de los que crecen en ambos suelos. El éxito sorprendente de estos árboles en esta región no es del todo comprobado por la deficiencia de nitrógeno en los suelos. Otros factores sugeridos tentativamente como contribuyentes son la iluminación relativamente buena en los niveles más bajos del bosque y la buena aereación del suelo.

Se suministran datos sobre varios aspectos biológicos del bosque, especialmente sobre la morfología de las raíces y aquellos aspectos que dan ciertos indicios sobre los procesos dinámicos en operación. Un estudio comparando árboles muertos con árboles vivos indicó que el porciento de madera muerta era más bajo en un bosque seco que en uno húmedo localizados en arena blanca y quizás más bajo aún en los suelos lateríticos.

Las cuatro leguminosas más importantes (**Eperua falcata, Dicymbe altsoni, D. corymbosa, Dimorphandra davisii**) sirven de ejemplo para demostrar los muchos fenómenos mencionados. La última especie en particular muestra muchos aspectos interesantes. Casi todas sus inflorescencias se caen al tiempo de florecer y desarrollan relativamente pocos semillones; en el bosque poco perturbado las plantas de esta especie no pasan del estado de arbolillo, pero algunas veces se produce la suficiente alteración por la caída de sus árboles lo cual entonces permite el desarrollo de sus arbolillos. Además, esos troncos caídos con frecuencia producen una hilera de arbolitos nuevos por reproducción vegetativa, uniendo las bases de los árboles nuevos con madera viva.

D. davisii por lo menos muestra alguna tolerancia a los incendios, y en partes del área quemada en el año 1926, es casi la única especie que se ha regenerado a pesar de que aún existen troncos muertos en pie de otras especies. Se sugiere que esta y otras especies de **Dimorphandra** podrían ser favorecidas por las quemas, y se advierte sobre los efectos a largo alcance de los incendios en estos bosques.

In any one small area of tropical rain forest it is usually possible to make subjective divisions of the forest types present, with generalizations on their structure and species components. For larger areas satisfactory theoretical classifications of the forest will have to wait for large-scale statistical surveys. However, in the Amatuk region of British Guiana, much of the forest may be classified into a few fairly distinct types, due to the nature of the soils, and the fact that the bulk of the canopy trees consist of only a few species. This paper is a brief description of these forest types, followed by a discussion of five aspects of their biology: forest type and diameter size distributions; dead trunks and tree fall; roots; reproduction; influence of fire. Many of the details under these sections are concerned with the same few dominant legumes, especially the biology of the most distinctive of these, *Dimorphandra davisii*.

The work described was carried out on the Oxford University Expedition to British Guiana, 1959, during the period July - September. Quantitative results given are derived largely from 4 m. wide transects, and various quadrats; in addition the Conservator of Forests has kindly permitted use of some figures obtained in Departmental surveys. Unfortunately transect lengths were not recorded accurately, and hence data given cannot be expressed as densities. Values are given in metric units except where these conflict with records made locally, as diameter size measurements and soil depths.

Identification of specimens collected and mentioned has been made by Mr. D. C. Reid and Mr. N. Y. Sandwith. Almost all the trees quoted were recognized in the field by the Arawak, Mr. Rufus Boyan. R. Boyan also gave much useful information about the biology of various species, and talks with him were particularly helpful in deciding whether or not tentative generalizations based on field observations were worth following up. Information on the past history of the Amatuk region was given by Mr. Elgin, a porkknocker who has lived for most of his life on that stretch of the R. Potaro.

ENVIRONMENT

Summaries, with maps, are given of much of what is known about the climate, geology, and soils of British Guiana by Davis (1941) and Fanshawe (1952).

LOCATION

The region studied was near the expedition's camp below the Amatuk Falls, on the Río Potaro, 135 miles from the Atlantic Ocean and 13 miles northwest of the Kaieteur

Falls. The area immediately adjacent to Amatuk lies in the lowland region, with numerous hills rising 30-60 m. above river level, and dissected by small streams and occasional larger creeks. Parts of the mountain escarpment, which runs across the interior of British Guiana, lie within a few miles of the camp; a steep-sloped mountain rising to over 600 m., Kanaima, is only 3 miles away.

SOILS

The three most important types are white sands, lateritic "ironstone", and those derived from rocks of the acid volcanic series. The last has forest quite different from the former two, not falling into easily distinguishable types and with many more species per unit area. This paper is concerned with forests on the former two types only, and generalizations do not include other forests unless specifically stated so. A full description of these soils will be published by Mr. D. Hopkinson, but some notes are included here.

WHITE SANDS. These cover much of the Amatuk region. The sands are of various grain sizes, usually much coarser than those typical of coastal regions. Large areas of white sands resembling those found over much of lowland Guiana are found further down the Río Potaro, and these bear typical wallaba (*Eperua* sp.) forest, dominated by *E. falcata* (Davis & Richards, 1933-34; Fanshawe, 1954; Schulz, 1960). This description will follow Forest Department practice in calling the more typical sands "fine" and those with much larger grain sizes "coarse". An "intermediate" grade will also be used. These distinctions are based on inspection of the surface sand only. Though the separation is probably arbitrary, there was sometimes a very sharp boundary between ridges of intermediate and of coarse grains, and the forest types then had equally sharp boundaries.

Percentages of different grain sizes are given in Table 1 for various samples of what were termed intermediate and coarse in field records.

Table 1. Percentages by weight of sand grains held between different pairs of sieves. Sieve values refer to the number of meshes per inch: that is the largest grains are in the column on the left, the smallest on the right.

Forest Type	Depth of Sample	Mesh Sizes of Sieve					
		10 %	10-20 %	20-40 %	40-80 %	80-120 %	120 %
"Intermediate" Sand							
A. Under forest burnt in 1926	top 2"	0.9	0.5	5.4	36.7	51.7	5.0
B. "Semi-wallaba" forest	top 2"	1.5	0.7	9.6	44.2	38.9	5.0
same pit as previous	at 12"	0.2	0.1	13.3	50.1	34.0	2.4
"Coarse" Sand							
C. *Dimorphandra davisii* *Dicymbe altsoni* forest	top 2"	1.3	0.8	32.0	49.3	14.3	2.3

White sand sometimes overlies clay, but hills which were known to have some sort of pan near the surface were not included in surveys. However it seems probable that all or most of the white sands in the Amatuk region are shallow compared with those farther to the north, although not necessarily more poorly drained. A coarse white sand overlying sandstone forms a narrow fringe round the edge of the gently sloping summit plateau of Mt. Kanaima.

The more poorly drained the sand, the greyer it is, and the more undecomposed organic matter it contains. Small earthworm casts are frequent in the wetter parts, occasional elsewhere, and large ones sometimes occur near streams.

IRONSTONE. The following is the profile of a pit dug by Hopkinson, on an ironstone bench, under *Dicymbe altsoni - Eschweilera sagotiana* forest:

0- 2" Dark-red ironstone gravel, the individual pebble typically 3-5 mm. across. Abrupt boundary to:

2- 6" Sticky grey-brown clayey gravel
6-29" Yellow-brown clayey gravel
29-45+" Orange-brown clay with deep crimson lateritized rock pseudomorphs

FIRE

Besides humic staining and unrotted organic matter, the surface layer of white sand may appear greyish due to the presence of charcoal. Charcoal lumps were found on four occasions under the roots of old fallen *Dimorphandra davisii* trees, and occasionally elsewhere. Inspection of the sand in the adjacent forest then showed traces of charcoal. Whilst the fires which led to the presence of this charcoal must have occurred long previously, details are known of a large fire which occurred in 1926, an extreme example of the drought years which themselves occur at 6-7 year intervals. Elgin reports that the fire swept from ridge to ridge, burning the forest out to varying extents from the region of the R. Ewang 5 miles downstream of Amatuk to near Kangaruma still further downstream, but hardly touching the lower lying forests near the creeks and streams. An aerial photo covering part of this region permits the approximate limits of this burnt area to be picked out.

CLIMATE

Local details of the general climatic pattern described by Fanshawe (1952) are known only for the period of the expedition, which was carried out during the last weeks of the long rainy season, and the beginning of the "dry" one. Short violent squalls often occurred before rain in the late afternoon or evening, during which time many branches fell. Frequently lightning could be seen in the evening, but this was centered on one area of the mountains to the southwest.

FOREST TYPES

On the white sand and ironstone soils, the greater part of the forest may be classified into 5 of the 27 formations recognized by Beard's (1955) terminology. These are: Rain Forest, Dry Rain Forest, Seasonal-Swamp Forest, Seasonal-Swamp Woodland, Mora Forest. However, many intermediates occur, particularly between Seasonal-Swamp Forest and Dry Rain Forest, and a residue does not fall well into any category.

Rain Forest covers the ironstone, and Dry Rain Forest the drier parts of the white sand. On low-lying, poorly drained white sand, Seasonal-Swamp Forest occurs, whilst a low Seasonal-Swamp Woodland covers the white sand fringe of the summit of Mt. Kanaima. Mora Forest occurs in low-lying riverain stretches only locally. Other riverain forest is variable in structure and species components, part of this no doubt being due to earlier human interference. A dense herb layer of Rapateaceae covers the ground where

the water table is near to or above the surface for at least part of the year, and on the white sand slopes the upper limit of the Rapateaceae coincides approximately with the transition from where the sand is markedly grey just below the surface to where the grains are but lightly stained in the upper 2-4" only.

The Dry Rain Forest of the white sand ridges (e.g. forest C in Table 1) differs in structure from wallaba forest, illustrating the wisdom of Beard's change in nomenclature in 1955 from Wallaba Forest to Dry Rain Forest. However, on the flatter areas with sand of intermediate grades, forest much more resembling wallaba forest occurs, and is here called semi-wallaba forest (e.g. forest B in Table 1). As stated above true wallaba forest occurs on fine white sand. A number of differences in structure occur between these forest types, as will be pointed out later, but the most obvious is the abundance of saplings in the 2-10 ft. height range in semi-wallaba forest, as compared with their lower density on coarse white sand ridges (Table 2).

As a generalization on the floristic composition of forest on white sand hills compared with ironstone ones, it may be said that many of the canopy trees on the crests of the two types are the same, and similarly for the species of the slopes. The smaller trees generally, and the herb layer of moist parts, are rather more different, whilst the shrubs and herbs of the drier parts of the two soils are quite dissimilar.

Dicymbe altsoni, *Dimorphandra davisii* and *Eperua falcata* are the dominants of the white sand ridges, *Dicymbe altsoni* and *Eschweilera sagotiana* of the ironstone ridges. *Dicymbe corymbosa* is the main canopy tree on the slopes of both soil types, except for gentle ironstone slopes near the river, where it is replaced by morabukea (*Mora gonggrijpii)* forest. Unlike the situation on white sands, *Eperua falcata* is abundant on ironstone only in the wettest parts. Two other canopy trees are frequent on white sand hills: *Ormosia coutinhoi* and *Aldina insignis*. The latter shows a preference for wetter places, and is an important riverain species, exceptionally frequent in the Amatuk region. All the above named species except *Eschweilera sagotiana* are legumes.

Many of the commoner understorey trees on white sand are legumes also *(e.g. Cassia apoucouita*, four *Swartzia* spp.), this apparently not being the situation in the coastal white sand regions of Guiana. The commonest of these, *Macrolobium montanum* var *potaroanum*, is especially characteristic of this region. Fanshawe (1952) quotes *Macrolobium suaveolens* for similarly coarse sands further inland (north of Ayanganna).

All the common canopy legumes of the white sand except *Dimorphandra davisii* and *Ormosia coutinhoi* occur also on ironstone. *D. davisii* is endemic to the Pakaraima Mountains and the adjacent lowland region.

In the Seasonal-Swamp Forest there is less tendency for any one species to become dominant, mainly because with the more open forest canopy, there are fewer large trees per unit area. Another difference between stands of Seasonal-Swamp and Dry Rain Forest is that legumes play a less important part in the former, and the data given in Table 3 suggest that for white sand, the better the drainage, the more important part legumes play in the forest. Sufficient figures are not available for a similar comparison on ironstone soils, but the abundance of *Dicymbe corymbosa* on poorly drained ironstone indicates that the same generalization does not hold here.

Whilst there are similarities between ironstone and white sand ridges, there are also some species (e.g. *Catostemma commune)* which are found on ironstone ridges and in Seasonal-Swamp Forest, but not on white sand ridges.

Tovomita spp. show an exceptionally clear-cut distribution. Six species of these understorey trees are found in the Amatuk region, with one exception each being restricted to

Table 2. A comparison of the individuals falling in different height classes on 12.5-metre square plots: A is "semi-wallaba" forest on intermediate sand; B is "Dimorphandra davisii - Dicymbe altsoni" *forest.*

Height Range	A		B	
	Legumes	Non-legumes	Legumes	Non-legumes
0-1 ft.	28	155	52	169
1-2	124	231	149	209
2-3	8	201	11	67
3-4	3	99	5	30
4-5	1	47	2	25
5-6	1	66		12
6-7		22		14
7-8		25	2	15
8-9		10	2	8
9-10		19		14
10-11		16		14
11-12		8		5
12-13		8		2
13-14		7		3
14-15		13		4
15-16		15		5
16 +		26		15

a particular type of vegetation in which they are frequent. Two occur in Dry Rain Forest, and one in each of the following: riverain scrub, riverain forest, Seasonal-Swamp Forest, ironstone forest. The exception is the occurrence on white sands near rivers of the Dry Rain Forest species mixed with the riverain species. Both of the two Dry Rain Forest species occur in forest on coarse and intermediate white sands, with a similar relative frequency in each (2:5).

FOREST TYPE AND DIAMETER SIZE DISTRIBUTIONS

Schulz (1960, Section IV.2) discusses diameter-class representation of trees in Suriname Rain Forest stands in order to obtain some understanding of regeneration processes. The following notes may be considered as supplementary to Schulz's discussion. The studies made were aimed principally at finding out whether or not the same species growing on different soils differed conspicuously in diameter size distributions.

Table 4 gives details available for 3 legumes and 2 non-legumes included in transects on various soil types. Some values from a Forest Department survey ("Durban") are included also, as Boyan states that it was

Table 3. Total living trees 12" diameter and over listed in 7 transects, giving a breakdown of percentages legumes and non-legumes. The transects on white sands are listed in estimated order of drainage conditions.

Transect	Soil	Drainage	Total Trees	Legumes	Non-legumes
1	coarse sand	ridge	77	69%	31%
2	intermediate sand	slope	69	63	37
3	intermediate sand	flat, well-drained	117	62	38
4	ironstone	ridge	62	41	59
5	coarse sand	low-lying, poorly drained	42	31	69
6	ironstone	moist ground at foot of hill	68	42	58
7	white sand	extreme Seasonal-Swamp	58	26	74

made almost entirely in wallaba forest on fine white sand. After conclusions given in this section had been suggested by transect results, they were all checked by further field observation.

LARGER DIAMETER SIZES

Dimorphandra davisii may occasionally be the only canopy tree present (e.g. near Tumatumari, according to local helpers), though in the Amatuk region it always occurs along with the other dominants of white sand forest mentioned earlier. Here it comprises 20-80% of trees 20" diameter and over on white sands, the higher values being recorded from surveys along the ridges of the coarsest sands. The relative proportion of the larger diameter classes varies considerably with the different forest types. In pure forests, T. A. W. Davis has recorded diameters up to 48", but in the Amatuk area 36" is the usual maximum. Diameters above 28" are rare in forests other than those on coarse white sands, whilst such trees are the most characteristic feature of coarse white sand forest. Evidence that this last feature is determined by habitat rather than by past historical causes is provided by the fact that in a special survey of *D. davisii* in intermediate white sand forests, the total dead trees of 24" class and over exceed living trees in the same classes (11 vs. 7).

Whilst trees of large diameter are conspicuous immediately on entering forest on coarse white sand ridges and slopes, a feature of wallaba and semi-wallaba forest is that trees seldom exceed 28" diameter. The low maximum diameter class of *Eperua falcata* itself may perhaps be determined genetically, for no tree in 28" class was found on any soil type in the Amatuk region. On the other hand, the low maximum diameters in the semi-wallaba forest are perhaps determined environmentally in the cases of *Dimorphandra davisii* and *Dicymbe altsoni*. This latter seldom exceeds 24" in semi-wallaba forest, but trees of greater classes are frequent on coarse white sand and ironstone.

SMALLER DIAMETER SIZES

Schulz mentions that when such strongly light demanding species as *Goupia glabra* and

Table 4. Comparison of diameter size distributions of 5 tree species on coarse, intermediate, and fine grade dry sands, and on ironstone hills. Data for "fine" sand obtained from Forest Department records. Transect numbers refer to Table 3 also.

Species	Transect	Diameter Class						
		4"	8"	12"	16"	20"	24"	28"+
A. Coarse Sand								
Catostemma altsoni	1	4	9	3	0	0	0	0
" "	8	1	4	2	0	0	0	0
C. fragrans	1	1	4	0	0	0	0	0
" "	8	1	2	0	0	0	0	0
C. altsoni / C. fragrans	total	7	19	5	0	0	0	0
Dicymbe altsoni	1	4	6	10	5	0	1	0
" "	8	4	4	7	6	4	3	2
" "	total	8	10	17	11	4	4	2
Dimorphandra davisii	1	1	1	2	5	3	2	6
" "	8	1	1	2	2	1	0	1
" "	total	2	2	4	7	4	2	7
Eperua falcata	1	9	9	7	1	1	0	0
" "	8	8	10	5	5	0	0	0
" "	total	17	19	12	6	1	0	0
B. Intermediate Sand								
Catostemma altsoni	3	3	3	2	2	0	0	0
" "	2	2	2	1	1	0	0	0
C. fragrans	3	2	1	1	3	0	0	0
" "	2	1	1	1	0	0	0	0
C. altsoni / C. fragrans	total	8	7	5	6	0	0	0
Dicymbe altsoni	3	4	4	5	10	3	1	0
" "	2	3	4	9	6	2	1	0
" "	total	7	8	14	16	5	2	0
Dimorphandra davisii	3	2	2	5	5	3	2	0
" "	2	1	0	1	2	2	8	2
" "	total	3	2	6	7	5	10	2
Eperua falcata	3	23	15	5	3	4	1	0
" "	2	19	6	5	4	1	0	0
" "	total	42	21	10	7	5	1	0
C. Fine Sand								
Catostemma altsoni / C. fragrans	records	5900	3445	1261	291	10	10	0
Epercua falcata	records	16100	10750	7530	4170	2140	155	29
D. Ironstone Hills								
Dicymbe altsoni	4 + 6	5	13	7	6	3	3	3
Eperua falcata	6	8	7	8	4	1	0	0

Simarouba amara are found in primary forest, they generally show a marked deficiency in the lower and/or middle size classes. A search through Forest Department records showed one further example of a similar, though not so extreme, species. This is *Peltogyne pubescens*, where the 8" and 12" classes (283, 174 respectively) exceed the 4" class (142). However, in the Amatuk region, there are a number of examples of species showing an excess of 8" class over 4" class, and data illustrating this are given for 5 species in Table 4. *Dicymbe altsoni* and *Dimorphandra davisii* show this phenomenon on all soil types, whilst *Eperua falcata* and *Catostemma* spp. show it on coarse but not on intermediate grade sands. There is no difference in the relative distributions of total trees in the lower diameter size classes in transects on the two sand types.

The capacity of the three legumes for variation in pattern of distribution of lower diameter sizes is the opposite of the situation with the higher diameter classes. With the lower sizes, *Eperua falcata* differs on coarse and intermediate sands, whilst *Dicymbe altsoni* and *Dimorphandra davisii* are similar: as mentioned above the converse is true with the larger diameters.

There is another group of species which show excess of 8" over 4" class. These are a few of the smaller trees of moist or swampy conditions, where the canopy is more open. Here the trees seldom exceed the 8" or 12" classes. Examples are given in Table 5.

The data recorded from transects indicate that true understorey trees do not show this phenomenon, but have a steady fall-off in numbers with increasing diameter size class. However it is possible that the large (4") size class intervals obscure the true situation here.

TRUNK MORPHOLOGY

A striking morphological difference between trees growing in different forest types lies in the branching of the trunk. Those of *Ormosia coutinhoi* frequently and of *Dimorphandra davisii* occasionally branch into two equal vertical parts at about 10m. from the ground in semi-wallaba forest, but a similar phenomenon was never noted in the same species when growing on coarse white sands. It may however be mentioned here that the main trunk of *Dicymbe corymbosa* invariably dies off early, and mature trees consist of a large base splitting into five to ten separate trunks, each 4-12", at about 2 m. above ground level. The very closely related *D. altsoni* has a single trunk, but this is often surrounded by several large shoots arising near its base, and sometimes reaching 2-3" diameter.

Table 5. Distribution by diameter class of various species growing on moist ground and showing excess of 8" over 4" class

Species	Transect	Diameter Class					
		4"	8"	12"	16"	20"	24"
Cassia pteridophylla	various	15	18	1	0	0	0
Hevea pauciflora sensu Schultes	various	18	26	12	0	0	0
Macrolobium acaciaefolium / *M. bifolium*	records	371	471	29	0	0	0
Symphonia globulifera	records	40	51	19	6	10	0

DEAD TRUNKS AND TREE FALL

Another approach towards understanding some aspects of forest regeneration was made by studying the recently fallen trees and older dead trunks present in the area. The information gained was very fragmentary, but is described here nevertheless, due to the lack of such data from tropical rain forest. There would seem to be no inherent difficulties in studying the dead trees present, except for the fact that surveys are required over much larger areas than for living trees. This involves not only more time, but also the difficulty of finding large enough areas of similar forest for comparative studies. Such a study could better be carried out in a district where the pattern of distinct forest types is on a larger scale than in the Amatuk region.

Dead trees were included in the initial forest transects made, as described below, but when it was realized that it would be impossible to obtain sufficient data for statistical comparison in the time available, a number of day trips into the forest were made for the specific purpose of making general observations on tree fall. Conclusions given below and not backed by figures are the result of these trips, and should be treated with caution. They are dealt with under three headings: dead trunks, fall of individual trunks, causes of fall.

DEAD TRUNKS

Comments on trunks lying on the ground

Figure 1. Roots running through old dead trunk.

Figure 2. Abundant nodulated roots in old DICYMBE ALTSONI stump.

are included sometimes with descriptions of natural forests, but these do not seem to have been expressed quantitatively, either on a numerical or volume basis. Nevertheless photographs inside natural forests from different parts of the world suggest that the amount of dead timber lying in such forests varies considerably, the author's impression being that relatively more dead timber is present in forest of cool wet regions (e.g. New Zealand, Chile) than in British Guiana. It would be of interest to know whether or not this is merely a photographic artifact.

In the Amatuk region fallen trunks of the commoner species could usually be found in all stages of decay down to where only a few rotting lengths lie on the surface of the soil. For some of the transects made, fallen or dead trunks were included in a manner similar to living ones. When present in the transect, a fallen trunk was included if its original base lay within the transect, and at least 10 ft. of timber remained which more or less retained its shape on being kicked hard. Such an arbitrary limit may not seem very satisfactory, but there were only a couple of doubtful cases out of two hundred fallen trees. This may be due to the fact that for many species it seems that the initial stages of decay are very slow, whilst the final fragmentation of the trunk, which involves the action of roots and termites, is rather rapid. If the tree was still standing, though

Table 6. Transects showing both living and dead trunks in various diameter classes, together with dead trunks in a diameter class expressed as a percentage of fall in number between this and the next diameter class. Transect numbers are identical with those described in Table 3. Transect 9 is on moist coarse sand (not Seasonal-Swamp)

Transect	Conditions	Item	Diameter Class						
			4"	8'	12"	16"	20"	24"	28"+
1	Dry sand	Living	113	61	46	15	5	5	6
		Fall	52	15	31	10	0	-1	
		Dead	11	20	6	4	2	0	0
		%	21	133	19	40			
2	Dry sand	Living	67	41	31	19	6	10	3
		Fall	26	10	12	13	-4	7	
		Dead	7	9	3	8	0	1	0
		%	27	90	25	61			
3	Dry sand	Living	130	93	50	41	17	9	0
		Fall	37	43	9	24	8	9	
		Dead	13	16	10	2	0	1	2
		%	35	37	111	9			
5	Moist sand	Living	90	35	21	12	3	5	1
		Fall	55	14	9	9	-2	4	
		Dead	12	10	7	5	2	1	0
		%	22	71	78	56			
7	Moist sand	Living	48	66	45	6	5	1	1
		Fall	22	21	39	1	4	0	
		Dead	4	11	5	3	6	0	0
		%	18	52	13				
9	Moist sand	Living	25	17	12	3	1	0	0
		Fall	8	5	9	2	1	0	
		Dead	2	8	1	2	0	0	0
		%	25	160	11				
4	Dry ironstone	Living	82	65	33	14	7	4	4
		Fall	19	32	19	7	3	0	
		Dead	12	5	4	1	0	0	0
		%	63	16	21				
6	Moist ironstone	Living	71	65	39	20	7	2	0
		Fall	16	26	19	13	5	2	
		Dead	14	3	2	4	0	0	0
		%	87	12	11				

completely dead, it is included, but if the tree broke off originally below 10 ft. level and only the standing base remains strong enough to withstand kicking, as sometimes occurred with *Tovomita* spp., it is not included. Diameter sizes recorded refer to Boyan's estimate of original diameter where this has been reduced, as by the bark falling off.

The values obtained in the initial transects are shown in Table 6. In addition, the ratio of dead trees in the lower size classes is expressed as a percentage of the fall in number of trees between this and the next larger size class. Whilst this is a function of too many variables (time of decay of trunks, time of persistence of living trees in the two size classes, number of trees dying between the two limits) for detailed discussion, it is suggested that this ratio is a useful empirical indicator of similarities in the dynamic processes operating in the forest types.

Table 7 is an estimate of the comparative volumes occupied by dead trunks in the different transects. It is calculated by dividing the (cube[1] of mid-diameter in a size class times the number of trees in this class) for total dead by a similarly determined value for living trees. It was estimated that an approximate indication of the actual volumes of dead compared with living timber may be made by halving the percentage values given

Table 7. Comparative index of dead with living timber present in transects described in Table 6. Index is based on the cubes of the diameters, the true values for volumes of dead timber as percentage of living timber are probably about half the values given by the index. (See text)

Transects	Conditions	Index of dead/living timber
		%
1	Dry sand	14.0
2	Dry sand	15.4
3	Dry sand	14.4
5	Moist sand	30.3
7	Moist sand	32.1
9	Moist sand	24.8
4	Dry ironstone	4.8
6	Moist ironstone	8.4

in Table 7. The results indicate that there are wide differences in the dead timber component of the ecosystem although too much importance should not be placed on these results due to small size of transects. The difference between the values recorded on white sand for moist and dry forests is significant, and of the two transects on ironstone, the one on moist soil has again the higher percentage dead timber. The explanation may possibly be a historical one due to fire, rather than a direct environmental one.

1/ Slightly exaggerates the volume of large trees, but saves making a detailed study of height diameter relationships.

Contradictory to the low values recorded for transects on ironstone is the impression of R. Boyan that fallen trees are almost always more conspicuous on lateritic soils or those with a hardpan, than in true wallaba, mixed, or greenheart (*Ocotea rodiaei)* forest. *Ocotea rodiaei* itself is known to be very resistant to decay, and Jonah Boyan reported that a trunk cut down by the 1929 Expedition to Moraballi Creek is little changed. It would be of interest to compare dead : living trees of this species in forests where it is frequent, at the centre and edges of its range, as it has been suggested that it may still be spreading.

The fallen trunks of *Dimorphandra davisii* are exceptional in that often they give rise to a row of 3-5 new trees, and, as will be discussed later, part of the old fallen trunk is frequently still alive. Figure 3 shows the end tree of such a row.

FALL OF INDIVIDUAL TRUNKS

Some trees fall such that the trunk is broken, leaving the roots and stump, usually 1 - 2.5 m. tall. Figure 2 shows such a stump, a 16" diameter *Dicymbe altsoni.* Others pull most of their roots out when falling, as with the case of the old *Dimorphandra davisii* in Figure 3. This sometimes leads to as many as six other trees falling at the same time. On steep rocky slopes probably the majority of trees fall such that their roots are pulled out, and this is perhaps a contributory factor

Figure 3. Young DIMORPHANDRA DAVISII tree arising from old fallen one.

Figure 4. Growth form of DIMORPHANDRA DAVISII sapling in the light.

to the low height of such forest. Large trees had frequently pulled out their roots on the lateritic ironstone hills, and it is in this type of forest in particular that cases were noted where the fall of a single tree had led to quite large gaps being formed in the forest. (No such gap was crossed by the two tran sects on ironstone in Table 7). On the white sands pulled out roots were noted only for 20" and over specimens of *D. davisii*, and even here its fall seldom led to such large gaps as that of *Dicymbe altsoni* on the ironstone. The reasons for this may perhaps include the facts that large roots run further and are more concentrated on the surface on the ironstone than are the respective cases with white sand species.

It is possible that whether or not the tree is hollow at time of fall is another factor affecting method of fall. *Dimorphandra davisii* trunks up to about 20" are solid and snap across, whilst larger trees are partly hollow and pull out their roots. A similar situation seems to hold in *Eperua falcata*, where the largest specimens start to become hollow, and sometimes pull out their roots when falling, instead of breaking as do smaller specimens. According to Boyan, *Ocotea rodiaei*, which is solid, breaks across the base of the trunk even at 36" diameter.

The importance of the nature of the main root, and whether or not a buttress is present, in affecting the pattern of fall of the largest

trees seems more certain. Specimens of big fallen trees with their roots exposed never show a large tap-root. In case of *Dimorphandra davisii*, though great mounds are produced at the base of the tree due to massive root anastomosis, the actual tap-roots, which sometimes fork into two, have usually tapered to a diameter of 10 cm. by a depth of 1 m. Similarly, in the cases of *Mora excelsa* and *M. gonggrijpii*, both large buttressed trees, fallen specimens with their roots pulled out of the soil show a considerable development of their main lateral roots, but with only comparatively short tap-roots. For instance, a large *M. excelsa* had its tap-root narrowed to 6 cm. by a depth of 1½ m. No specimen of *Eschweilera potaroensis*, the other important large buttressed tree, was found to have fallen in the same manner, though several cases were noted where the old trunk had broken across just above the buttress. Boyan suggests that all *Eschweilera* spp. may have long tap-roots. During road making operations on a loamy soil, Boyan reports that *E. sagotiana*, a mildy buttressed tree, had to be dug out to a depth of 6 ft. before the trees would fall and pull out their roots, and that the tap-roots reached at least 12 ft.

In the case of clump wallaba (*Dicymbe corymbosa*), the original trunk breaks across; when the other trunks eventually decay, they fall off one by one, leaving the base.

CAUSES OF FALL

The above discussion makes no mention of the more immediate cause or causes of fall, for it is difficult to be sure what is the relative importance of the various causes at any one spot, especially whether or not parasitic fungi have been a contributory cause of tree death, and perhaps of method of fall also. In the region studied short violent gusts of wind are probably the most frequent cause of tree fall. Sometimes a recently fallen tree has polypore fruit-bodies on it, but not uncommonly apparently healthy specimens of the same tree may be found standing with some of the brackets emerging from their trunk. At least some of the polypores are common, and found on various species. The following five were collected as being among the commonest of those species which seemed likely to prove parasitic on further investigation. The trees on which the collected specimens were growing also listed, and were all either dying or recently dead: *Ganoderma* aff. *applanatum* (Pers. ex Wahlr.) Pat. on *Eperua falcata; Polystictus hammatus* (Rom.) Sacc. on *Dimorphandra davisii; Trametes corrugata* (Pers.) Bres. on *Catostemma altsoni; Daedalea sprucei* Berk. on *Eperua falcata; Ganoderma* aff. *lucidum* (Leyss. *ex.* Fr.) Karst on *Eperua falcata.*

Two gaps in the semi-wallaba forest were of special interest. Here a number of trunks had fallen in all directions at one spot, leaving a marked gap in the forest, and all the trunks were connected up by numerous black rhizomorphs above and below the sand surface. But it was impossible to infer whether this considerable fungal growth was the cause or effect of the fall. Black mycelial wefts were most frequently noticed, otherwise, associated with the underground parts of various shrubby Rubiaceae.

Two hundred yards below the Amatuk Falls, there is a low lying part of the riverain forest, where the lower parts of the tree trunks are submerged by several feet of water for a total of about four months a year. On this flat low-lying sand, fallen trunks were especially noticeable, and R. Boyan volunteered that he had often noticed such patches of forest full of fallen trunks in riverain forest just below big waterfalls.

ROOTS

Root-system morphology will be considered under five headings: tap-roots, larger horizontal roots, stilt roots, fine roots, seedling roots.

TAP-ROOTS

Some notes on these are included above,

but too little is known to generalize.

LARGER HORIZONTAL ROOTS

Whilst the finer roots are usually concentrated in the upper few inches of soil in the Amatuk region, the larger ones may be concentrated above, intermingled with, or mainly below them.

A dense tangle of roots lying on the surface of the ground is especially characteristic of soils with an upper layer of red ironstone gravel, and of some of the riverain and creekside vegetation. Myers (1936) describes the various types of forest in the region of the Ireng Falls, and at the base of Mt. Roraima. He records that in the montane rain forest and asheroa forest there is a snaky tangle of roots which cover the ground to a depth of 1 ft., and are densely covered by a thick layer of dead leaves. Similar conditions prevail occasionally in the Amatuk - Kaieteur region on steep mountain slopes where the thick root layer rests directly on sandstone rocks, and spreads over the gaps between the rocks, even where these are several feet across. Typical species of such places are *Zizyphus cinnamon* and *Symphonia globulifera.*

On the lowland ironstone ridges the larger roots run mainly along the surface or are half-submerged, and many of the 1-2 cm. diameter roots run in the top 2" of soil, though some are scattered at much greater depths.

On white sand, the distribution of horizontal roots in the Seasonal-Swamp Forest is similar to that of the ironstone ridges. On white sand ridges however, whilst some of the largest roots emerge above the surface, most of them occur beneath it, intermingled with the dense fine root layer of the upper 2", aggregated especially just below this layer. The extreme of this series of root distributions was found in a young *Dimorphandra davisii* forest grown up since the 1926 fire on a white sand hill plateau. All the larger, and almost all the 1 cm. diameter roots were below the fine nodulated ones, these arising from vertical branches of the smaller horizontals.

It thus seems that the vertical distribution of horizontal roots is characteristic for the various soils and drainages. It is tentatively concluded that they tend to lie on the surface or half-submerged where the ground is very hard, half-submerged where the ground is seasonally flooded, almost completely submerged on drier white sand, the drier this being, the deeper the roots. However there are many exceptions to this scheme. For instance, a dense tangle of roots runs along many of the older fallen trunks, especially in the moister white sand forests. Groups of more or less parallel roots are frequent even where no rotting remains can be seen, though presumably they were originally associated with rotting trunks. (See Figure 1).

As the horizontal roots are more submerged on white sand ridges than on ironstone, it is difficult to compare their horizontal extensions. The lengths of the roots which were followed from the base of the tree to where they had tapered to 3 cm. indicate that greater horizontal extension occurs on ironstone, including the instance of *Dicymbe altsoni* which occurs on both soils. Unlike the parallel situation with branches of the tree canopy, roots of any one large tree usually extend almost to the bases of the other large trees adjacent. On ironstone the characteristic barks of a particular species can be followed to within half a metre of the base of another tree of equal diameter class 10 metres away e.g. in the case of a *Dicymbe altsoni* to an *Eschweilera sagotiana.*

Other than two special types of anastomosis in *Dimorphandra davisii* no case of root anastomosis was found.

STILT ROOTS (OF TOVOMITA SPP)

The five *Tovomita* spp. which are trees all have stilt roots. The order of size of

stilts reached by the species of a particular habitat, together with a typical value for the larger stilts of mature tree is: Seasonal-Swamp (8 ft.); riverain forest (6 ft.); ironstone (4 ft.); dry white sands (3½, 2½ ft.). The Seasonal-Swamp species is also the largest tree. For these species, the poorer the drainage, the larger the stilts, but Boyan reports that *T. grata*, one of the species identifed from the white sand forest, reaches 5 ft. in other regions, even in wallaba forest.

The tap-roots of single specimens of the Seasonal-Swamp and each of the two white sand species were dug out. All contracted abruptly below the surface, reaching only 30 cm. depth in the Seasonal-Swamp species, and slightly deeper in the other two.

FINE ROOTS

The great bulk of the fine roots is found within the top few inches of the soil, and as stated above, may lie below, intermingled with, or above the coarser roots which gave rise to them. On well drained riverain alluvial soils the fine roots occur throughout the top 12", and whilst they are more abundant near the surface, are not very markedly concentrated there. On the other hand in poorly drained parts of the riverain forest and Seasonal-Swamp Forest, fine roots are mostly within several inches of the surface, and many may be exposed especially in the form of brush-like masses, lying in the water during the wet seasons, and on the surface of the soil or sand during other times. The bulk of fine roots on the ironstone ridges occurs within the top 4", but there is no sharp horizon above which they are confined. But on the drier parts of the white sand almost all the nodulated roots of the legumes are restricted to the top 2-3", and may or may not lie exposed on the surface.

The nodules of mature trees of the four most abundant legumes (*Eperua falcata, Dicymbe altsoni, D. corymbosa, Dimorphandra davisii* are indistinguishable, macroscopically at least. Broken stumps of fallen trees contain a dense mass of these nodulated roots filling all the outer parts of the trunk. A fresh weight measurement of the nodules in the 1 m. high stump of *Dicymbe altsoni* shown in Figure 2 showed that about four times the amount of nodulated roots occurred here as would occur in a similar area of sand as that covered by the base of the tree.

A typical piece of Rapateaceae zone (mainly *Spathanthus jenmani)* on coarse white sand was chosen and fresh weights recorded for all roots less than 1 cm. diameter for 2 m. square plots halfway between two big trees. The total tree root weight of 5220 g. as opposed to herb root weight of 227 g. gives a ratio of 23 : 1 for tree : herb roots. A sub-sample showed that a ratio of about half this value would have been obtained if only the ultimate root branches had been weighed.

When old *Dimorphandra davisii* trees produce mounds at their bases, these are covered by fine roots of the tree branching from larger roots arising further away from the tree. Frequently these are not nodulated, the only case found other than in seedlings where non-nodulated roots of the dominant legumes occurred.

TREE SEEDLING ROOTS

A study was carried out of the roots of first year tree seedlings. On white sand these can be removed fairly easily, and are mostly similar in form, with a straight stem and tap-root, scarcely branched, if at all. The tap-roots on ironstone are more twisted and have to be dug out with care. The study consisted first of all of digging out all the seedlings present in twenty-four 2-metre square quadrats on coarse white sand, and then of three-day trips with a spade along the tree transects described earlier.

The quadrats were all made in late August on a single hill, 8 being placed at each of 3 levels on the hill: ridge, slope, and moist

ground at the foot of the hill. They were sited away from the bases of large trees on spots chosen subjectively as having typical populations. Shoot and root heights and fresh weights were recorded for all legumes (except *Eperua falcata)* and *Licania* spp. occuring in the quadrats, together with *Hevea pauciflora* and *Ocotea canaliculata* "souriskin variety." The results are shown in Table 8. In some cases where species were represented at two levels, the values are combined. Root lengths of *Macrolobium montanum* var. *potaroanum* could not be measured accurately as this species has a very long fine end to its tap-root. Details of two populations from other soils are also included in the table (*Dicymbe altsoni* on ironstone, *Dimorphandra hohenkerkii* on sandstone). The table lists population size on a particular soil type, together with the mean and standard deviation for: shoot height, root length, shoot weight, root weight, shoot height/root length of individual specimens, shoot weight/root weight for individual specimens except where the values are bracketed. These latter refer to mean shoot weight /mean root weight, as here the root weights were too low for accurate measurement.

Interpretation of the results is complicated by the fact that the fruiting seasons of the species are not all the same, and hence populations are only strictly comparable within a single species. The mean lengths of roots of species (except *Macrolobium montanum)* on white sand range from 14.9 to 34.7 cm., compared with 10.8 cm. for *Dicymbe altsoni* on ironstone and 8.7 cm. for *Dimorphandra hohenkerkii* on ironstone. This greater depth of seedling roots on white sand was confirmed on the later day-trips. A scatter diagram (not illustrated here) of shoot height/root length plotted against shoot height shows that there is a general tendency for an increase in this ratio with increasing shoot height. Where populations are represented at drier and moister levels on the hill, shoot growth is in all cases lower at the better drained level, significantly so in the case of *Dicymbe altsoni.* However in the instances of *Dicymbe corymbosa* and *Ocotea canaliculata,* root growth is deeper at the drier level, and in all cases the shoot height/root length ratio is equal to or less than that at the moister level. Hence it may be concluded that growth is better in the moister parts of this coarse white sand hill, but in most species this is reflected in shoot length more than root length.

The much better growth of *Dicymbe altsoni* seedlings at the moist than at the drier levels is the converse of the situation with the mature tree.

The following notes are based on various trips. Tap-roots on white sand vary from being somewhat twisted or wavy (*Ocotea canaliculata)* to strikingly straight *(Hevea pauciflora).* About one-quarter first year canopy legume seedlings inspected were nodulated. These nodules resemble those of the mature trees, except for *Dimorphandra davisii* where they are elongated rather than rounded. The tap-roots of some of the shrubs do not always run straight down like those of the tree saplings, even on white sand. For instance, the main root of *Tococa aristata* often runs obliquely, and even horizontally when growing in riverain forest. Some of the perennial forest herbs and most of the early arrivals on clearings (Cyperaceae, Eriocaulaceae, Gramineae) have masses of adventitious roots. Several species of Melastomaceae would seem to be the first arrivals on clearings with long tap-roots like those of forest tree seedlings, though even these develop strong laterals at an early stage.

The adventitious roots of "annuals" of clearings mainly or entirely radiate out horizontally within an inch of the surface. Where these roots run both horizontally and vertically there are sometimes but few running in intermediate directions. *Zornia diphylla,* one of the two small common legume herbs of white sand clearings, has a few nodulated

Table 8. Comparison of shoots and roots of various seedling populations (mostly on coarse white sand - see text). Data are expressed in centimeters and grammes.

SPECIES	Soil	Drainage	No. Trees	Shoot Height	Root Length	Shoot Weight	Root Weight	Shoot Ht.: Root Length	Shoot Wt.: Root Wt.
Dicymbe altsoni	white sand	ridge & slope	26	39.3	22.8	6.1	1.7	1.8	3.8
"	"	moist	10	51.5	27.1	10.6	2.5	2.1	4.6
"	ironstone	upper slope	20	35.5	10.8	4.3	0.9	4.0	6.0
D. corymbosa	white sand	ridge & slope	14	31.8	29.2	5.6	2.3	1.2	2.8
"	"	moist	25	33.1	21.2	6.8	1.5	1.7	5.0
Dimorphandra davisii	"	slope	20	16.8	15.8	0.9	0.6	1.1	1.4
"	"	moist	4	20.3	22.4	3.8	1.7	1.1	2.8
D. hohenkerkii	sandstone	well drained	4	16.1	8.7	0.5	0.2	2.0	(2.5)
Hevea pauciflora	white sand	slope	4	57.1	31.4	11.6	4.5	1.9	2.5
Licania buxifolia	"	ridge	19	15.9	19.5	0.76	0.28	0.81	(2.7)
L. divaricata	"	slope	6	31.4	25.4	3.7	1.3	1.3	2.8
L. heteromorpha	"	ridge	19	16.1	19.9	0.68	0.30	0.79	(2.3)
"	"	slope	6	17.6	21.2	0.75	0.35	0.79	(2.1)
L. incana	"	slope	4	52.8	24.6	7.6	3.1	2.1	3.8
L. micrantha	"	moist	4	52.7	28.6	13.6	4.1	1.9	3.5
L. mollis	"	slope	4	67.7	34.7	12.3	4.0	2.0	3.3
L. persaudii	"	ridge	22	16.1	17.0	0.35	0.19	1.0	(1.8)
"	"	slope	5	19.3	21.2	1.0	0.38	1.0	(2.6)
Macrolobium montanum	"	slope	7	25.2	30-40	1.8	1.0	0.8	2.0
Ocotea canaliculata	"	ridge	6	35.5	16.6	3.1	0.6	2.4	7.1
"	"	slope	18	55.8	14.9	7.7	1.7	4.0	4.8

roots radiating out distances of a metre or more, these lying immediately below the surface. There are no legume herbs inside the forest.

REPRODUCTION

SEED BIOLOGY

First year seedlings of all the legumes mentioned earlier are frequent near the parent trees. Seedlings of *Dimorphandra davisii* are found only under the parent tree, but those of *Eperua falcata* and *Dicymbe* spp. are found up to 6 m. from the area under the crown of the tree. This is probably associated with the fact that *Eperua* spp. and *Dicymbe* spp. have explosive fruits, whereas those of *Dimorphandra* spp. and *Mora* spp. do not. All of these legumes have large seeds, those of *Dimorphandra* being the smallest, and of *Mora* the largest. According to local helpers, they are untouched by mammals, and this appears to be generally true of leguminous trees in British Guiana. One hundred seeds of *Ormosia coutinhoi* lying on the forest floor were observed at the beginning and end of a 4-week period, and none had disappeared during this time, though four germinated. R. Boyan did however claim that whereas the seeds of *Mora excelsa* remain uneaten around Bartica, they are eaten by rodents in the Pomeroom region.

REPRODUCTION AND REGENERATION OF DIMORPHANDRA DAVISII

Dimorphandra davisii flowered in September, and the majority of inflorescences fell off entire while the flowers were still open. Nevertheless there were many first year seedlings of this species, though less abundant than those of *Dicymbe* and *Eperua* spp. Older *Dimorphandra davisii* sedlings were rare, and no specimens were found inside the forest intermediate in height between 200 cm. and upper canopy trees, although all intermediates of the other important legumes occur. The older *D. davisii* saplings found were spreading and bushy, with short branches and many leaves.

However young plants of *D. davisii* are frequent in clearings where an old tree is adjacent, or trees have been cut down; these are quite different from the bushy saplings inside the forest and resemble in form many quick-growing light-demanding tropical species, Figure 4. In addition, felled trees and, in some cases at least, burnt ones send up numerous quick-growing sucker shoots. Where a large tree of *D. davisii* had fallen recently, leaving a light gap, young plants of heights not reached in undisturbed forest were frequent. This tree seems to be a species which can grow to maturity only in at-least partial clearings, the fall of its own trunk making a sufficiently large opening for growth in height to occur.

When large *D. davisii* trees fall pulling out their roots, they favour the reproduction of the species in quite another manner also. On such fallen trunks from 3 to 5 new trees usually arise, and these may reach 24" diameter whilst the old trunk still shows few signs of decay. Recently fallen trunks show a number of sucker shoots, sometimes also with seedlings of *D. davisii* or occasionally of other species e.g. *Pentaclethra macrolobium*. But at least the majority of the larger trunks would appear to have arisen by vegetative means. In the largest diameter classes, rows of *D. davisii* are conspicuous in the forest even where the old trunk has disappeared. When the old trunk remains, large roots come down over its surface, and enter the white sand, and these are probably part of the cause of the mounds beneath the base of the trunk of old trees, though this does not explain the presence of a sand layer overlying the large roots beneath. In addition there is frequently a cap of living wood running from the base of one tree to the next along the upper surface of the old fallen trunk. One fallen trunk was cut open half-way between two standing trees, and the surface cap at this point seemed to have arisen by cambial

growth subsequent to fall rather than by root anastomosis at this point. The cambium of the old cap is continuous on both sides with the cambium of the old trunk. Sap flowed out of the cut cap in both directions.

DIMORPHANDRA AND FIRES

Whilst much of the drier parts of the white sand was covered with only scattered fallen leaves, there was a dense layer under trees of *Dimorphandra davisii*, from 2-4" thick. Other species of *Dimorphandra* (e.g. *D. hohenkerkii)*, were seen to have or are known to have, similar or thicker layers of dead leaves, which reach 18" deep in pure *D. conjugata* forest. It is well known among local helpers that such forests of *D. conjugata* are a fire hazard.

It has been suggested that various low forest and scrub types in Guiana with abundant growth of coppiced *D. conjugata* may be fire climaxes. Several lines of evidence indicate that the relative abundance of *D. davisii* is also favoured by the occurrence of fires. Over parts of the area of the 1926 fire, there are still large patches of bare sand showing that recolonization is very slow. *D. davisii* is almost the only tree regenerating, though many dead standing trunks of other species *(Eperua falcata,* ? *Catostemma* sp.) may still be seen among the young *D. davisii* trees. The presence of lumps of charcoal mixed with the upturned roots of *D. davisii* at other sites is also suggestive. It is well known that many forest types in Guiana have only a few dominant tree species, but the single species dominance of some stands of *D. conjugata* and *D. davisii* are exceptional amongst even these.

Whilst *D. conjugata* was not found in the Amatuk - Kaieteur region, two other species of *Dimorphandra* were: *D. hohenkerkii* and *D. cuprea. D. hohenkerkii* occurs near the periodically burnt camp site at Tukeit and in the Dry Evergreen Forest on an adjacent sandstone mountain summit. In other parts of Guiana it is frequent in *D. conjugata* forest. *D. cuprea* occurs in Dry Evergreen Woodland and scrub above the Kaieteur Falls which also seems likely to have been burnt over in the past. Hence it seems likely that tolerance of fire damage is a widespread feature in the genus *Dimorphandra.*

DISCUSSION AND CONCLUSIONS

From the data presented it does seem possible to make a few general conclusions or raise important queries.

DOMINANCE OF LEGUMES

No doubt the nodules of these legumes will one day be shown to be capable of nitrogen fixation, which would help to explain their success in soils of very low nutrient content (see Schulz, 1960, for analyses). However it does not seem quite adequate as an explanation of their relatively great abundance on white sand and ironstone compared with other soil types like the clays of the acid volcanic series. It is possible that some obscure factor like relative micronutrient abundance is operative, but two further suggestions are indicated by data given above.

1. That legumes may be at a relative disadvantage under conditions of poor aeration. This is suggested by the fact that nodulated roots are all concentrated in the top few inches of soil, and that legumes were shown to be less important on moist than on dry white sand.

2. That legumes may be at a relative disadvantage at the lowest light intensities. No light data is available, but the forests discussed are all probably relatively well illuminated at ground level, that on coarse white sand more so than semi-wallaba forest. It is suggested that capacity for especially rapid growth under these conditions may explain the low 4" diameter class : 8" diameter class found for various species in coarse

white sand forest. Also saplings of the dominant legumes discussed all do exceptionally well at the edge of clearings, the extreme being the case of *Dimorphandra davisii* which can apparently only grow under such conditions. The legumes all have very large seeds suggesting the necessity for carbohydrate reserves to give rapid early growth. No legume herbs or shrubs exist inside the forest, although they occur on the same soils in clearings.

SAND AND FOREST TYPES

Differences in sand grain sizes are associated with differences in forest structure, structure in this paper being illustrated mainly by data on diameter size distributions and numbers of saplings in different height classes. However the causes of the difference are not obvious.

Large patches of bare sand were still present 33 years after a forest fire, and it may be expected that under such conditions many of the finer sand grains will be washed from the surface layers by the heavy rains. This raises the query whether the areas of coarse sand grains found nearer the Guiana escarpment are really causal factors in determining the species composition of the forest, or whether they are merely the effects of fire, with relatively little influence in determining the structure of the vegetation.

FIRE IN THE WHITE SAND FOREST

Evidence was presented above that fires have been important in the district, and that the abundance of *Dimorphandra davisii* is favoured by these fires. The poor regeneration of forest burnt in 1926, and the *D. conjugata* scrub present in other parts of B. Guiana suggest that forest may be reduced in complexity on burning, and it seems likely that fires may lead to a great loss of nutrients from easily permeable white sand ridges. N. Guppy (personal communication) reports that in the north of B. Guiana there are areas of white sand bare of vegetation except *Schizea* spp. and lichens, and it is suggested that these are the ultimate result of forest fires on ground where the nutrients released on burning are washed to a horizon below which any potential recolonizers can reach.

If most fires are caused by man rather than by lightning, and such changes have taken place mostly in recent times, it seems likely that the white sand forest will one day be mottled with patches of permanent desert, under 100" rainfall, unless adequate fire precautions are taken in the occasional years of extreme drought.

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double-spaced typewritten pages, although an occasional longer article of special interest may be acceptable. Articles should be submitted in the author's native tongue, and should include title or position of the author as well as a brief summary of the material. Manuscripts should be typewritten, double spaced, on one side of the page only, on 8½ x 11 inch white bond paper.

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Le "Caribbean Forester" est une revue semi-annuelle qui a été publiée depuis l'année 1938 en Puerto Rico por le Institut de Foresterie Tropique, Service Forestier du Départment de l'Agriculture des Etats-Unis. Cette revue est dediée a l'aménagement et a l'utilisation des forets surtout dans la region caraibe.

Par les pages de cette revue les personnes qui travaillent aux tropiques peuvent etre informées sur les problemes specifiques des forets tropicales et sur les travaux effectués pour realiser une ameilloration technique par l'aménagement et l'usage des resources forestiéres. Cette revue pourvoit aussi un moyen de destribuer l'information et les resultats obtenus par le programme experemental du Institut de Foresterie Tropique de Puerto Rico; en plus cette revue offre ses pages a les autres travailleurs forestiers des pays tropicaux pour qu'ils purssent publier les resultats de leur travaux.

Cette revue accepte volontiers des contributions ne depassant pas 20 pages dactilografiées a double espace, cependant que certains travaux du intéret spécial plus long purvent etre acceptés. Les contributions doivent etre ecrites dans la langue maternelle de l'auteur et doivent bien preciser son titre et sa position professionnelle, l'appert doct etre accompagné d'un résumé de l'étude. Les manuscripts doivent etre dactilografiées en double espace su du paper 8½ por 11 pouces.

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Les manuscripts doivent etre evnooyés a: "Director, Institute of Tropical Forestry, Río Piedras, Puerto Rico."

Nous voulons rappeller a nos lecteurs que les opinions expumées dans cette revue ne sont pas necessairement les opinions du Forest Service et que les articles publiés dans la revue le "Caribbean Forester" peuvent etre reproduits mais doivent jaire reference a cette revue.

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El Caribbean Forester es una revista semestral gratuita publicada en Puerto Rico desde el año 1938 por el Instituto de Dasonomía Tropical del Servicio Forestal del Departamento de Agricultura de los Estados Unidos. Esta publicación está dedicada a promover la mejor ordenación y utilización de los recursos forestales del trópico con especial énfasis a la región del Caribe.

Provee información a los que laboran en la dasonomía y ciencias afines sobre los problemas específicos que confrontan, las políticas forestales vigentes y el progreso del trabajo que se lleva a cabo para mejorar la ordenación y utilización de los recursos forestales tropicales. También sirve como medio informativo sobre los resultados y el progreso de los programas experimentales, en ordenación forestal tropical y utilización, que se llevan a cabo en el Instituto de Dasonomía Tropical en Puerto Rico. También le brinda una oportunidad a otras personas interesadas en la dasonomía tropical para presentar el resultado de sus trabajos.

Se solicitan aportaciones de otras fuentes en el campo de la dasonomía tropical siempre que no estén considerándose para publicación en otras revistas. El manuscrito generalmente no debe exceder 20 páginas escritas a máquina a doble espacio, aunque ocasionalmente podría aceptarse un artículo más largo cuando tuviera un interés especial.

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Los manuscritos deben enviarse al Director del Instituto de Dasonomía Tropical, Río Piedras, Puerto Rico.

Las opiniones expresadas en esta revista no coinciden necesariamente con las del Servicio Forestal. Los artículos publicados en el Caribbean Forester pueden reproducirse siempre que se haga referencia a la fuente original.

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The Caribbean Forester is a free semi-annual technical journal published since 1938 in Puerto Rico by the Institute of Tropical Forestry, Forest Service, U. S. Department of Agriculture. This publication is devoted to the development of improved management and utilization of tropical forest resources, with special interest in the Caribbean region.

Through the pages of the journal tropical foresters and workers in allied scientific fields are informed of specific problems of tropical forestry, policies in effect in various countries, and progress of work being carried out for the improvement of the management and utilization of forest resources. It furnishes a means of distribution of information on the progress and results of the experimental programs of the Institute of Tropical Forestry in Puerto Rico. In addition, it affords an opportunity for other workers in the field of tropical forestry to make available the results of their work.

Contributions for the journal are solicited. However, material submitted should not be under consideration for publication elsewhere. Manuscripts should not ordinarily exceed 20

(Continúa en la portada #3)

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Caribbean Forester

Contents

Sumario

Page

Descripción de Dos Nuevas Variedades del "Pino del Caribe" (*Pinus caribaea* Morelet) ---------- 59
Wilfredo H. G. Barrett y Lamberto Golfari

Key to Mexican Species of Pines ---------- 72
Elbert L. Little, Jr.

The Utilization of Teak Thinnings in Trinidad and Tobago ---------- 82
D. Moore

Prácticas Usadas en los Viveros de Pinos de Puerto Rico --- 87
José Marrero

The Breeding of Pine *(Pinus caribaea Mor.)* and Teak (*Tectona grandis* L.) in Trinidad - Some Early Observations ---------- 100
W. S. Chalmers

Leaf Size in *Swietenia* ---------- 112
C. B. Briscoe and F. Bruce Lamb

Tropical Forestry with Particular Reference to West Africa (Book Review) ---------- 116
C. B. Briscoe

Descripción de Dos Nuevas Variedades del "Pino del Caribe"

(*Pinus caribaea* MORELET)

por

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R E S U M E N

Debido a la confusión existente en la denominación y posición sistemática del "pino del caribe" que habita el litoral atlántico centroamericano, desde Honduras Británica hasta Nicaragua, se realizó un estudio morfológico y ecológico de esta entidad, comparándola con la forma típica existente en Cuba. Por otra parte, se amplió este estudio a las Islas Bahamas, con el objeto de abarcar toda el área de **Pinus caribaea** Morelet. Como resultado de las investigaciones realizadas en Centroamérica y Antillas, se subdivide la especie de la siguiente manera:

PINUS CARIBAEA Morelet var. CARIBAEA (típica)

Hojas de a 3, raro 4 por fascículo; conos de 5 a 10 cm. de largo; semillas con ala adherente. Habita en Islas de Pinos y Pinar del Río, oeste de Cuba, entre 45 y 355 m. de altitud, en clima tropical (temperatura media anual 24,5º - 25,5ºC), subhúmedo (lluvias anuales de 1200 a 1600 mm.), con seis meses de sequía; suelos ácidos (pH entre 4,5 y 6).

PINUS CARIBAEA Morelet var. HONDURENSIS nov. var.

Hojas de a 3, a veces 4 y 5 por fascículo; conos de 6 a 14 cm. de largo; semillas con el ala articulada (se desprende fácilmente), excepto un bajo porcentaje. Habita en la vertiente atlántica de Honduras Británica, Guatemala, Honduras y Nicaragua, desde el nivel del mar hasta 850 m. de altitud, en clima subtropical o tropical (20º - 27ºC), de subhúmedo a perhúmedo (lluvias anuales de 950 a 3500 mm.), con un período de sequía de dos a seis meses; suelos ácidos (pH 4 - 6,5).

PINUS CARIBAEA Morelet var. BAHAMENSIS nov. var.

Hojas de a 2 y 3 por fascículo; conos de 4 a 12 cm. de largo; semillas con ala articulada, raramente adnata. Habita en Islas Bahamas: Grand Bahama, Great Abaco, Andros, New Providence y Caicos, desde el nivel del mar hasta 30 m. de altitud, en clima tropical (25ºC), subhúmedo (lluvias anuales de 750 a 1300 mm.) con un período de sequía de seis a siete meses; suelos alcalinos (pH 7,5 - 8,5).

S U M M A R Y

Because of the confusion in the nomenclature and taxonomic position of "Caribbean pine" growing on the Atlantic slopes of Central America from British Honduras to Nicaragua, it was necessary to study this pine morphologically and ecologically and to compare with the typical Cuban form. This study was extended into the Bahamas Islands with the aim of covering the whole natural range of **Pinus caribaea** Morelet.

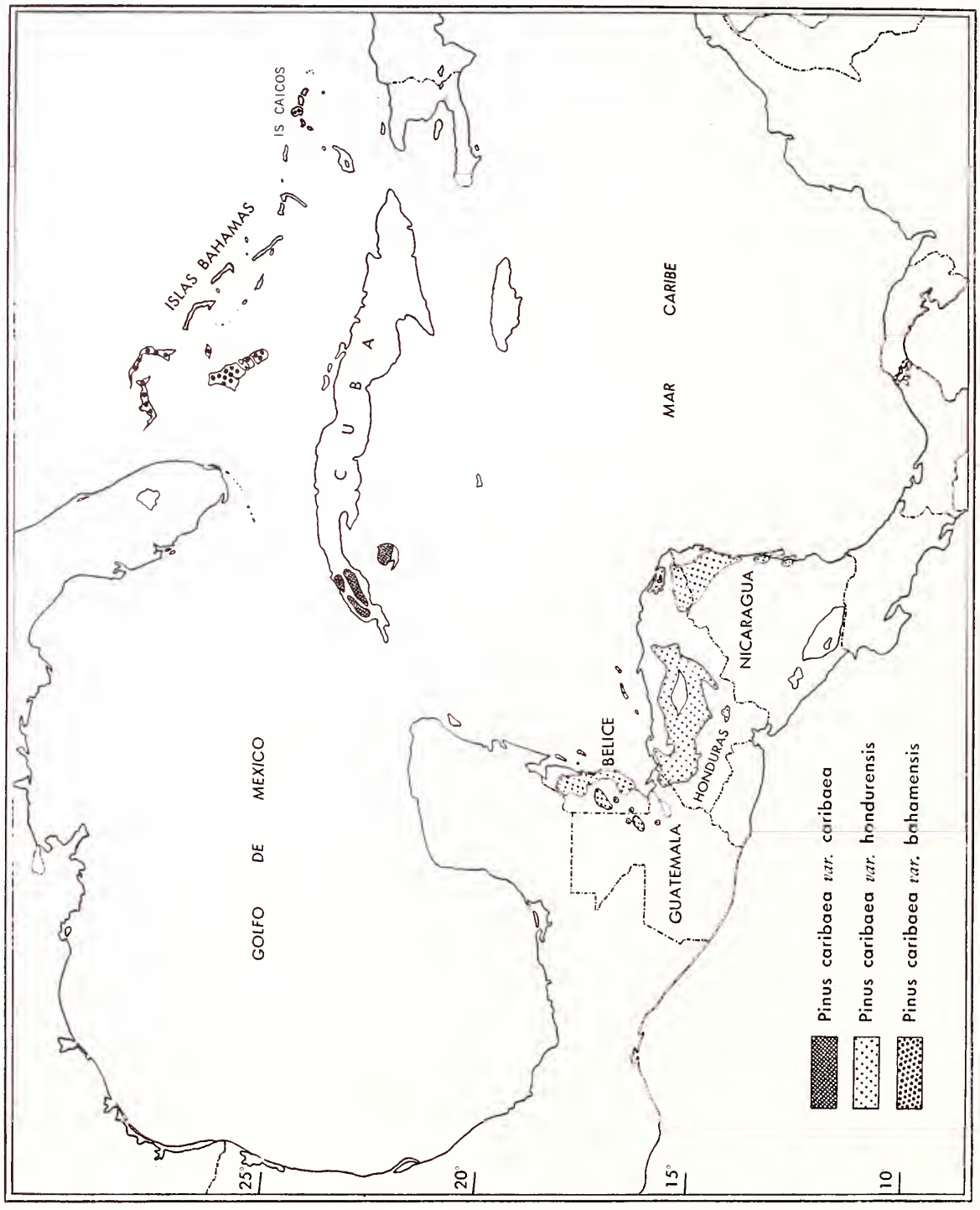

Figura 1. Distribución geográfica de Pinus caribaea Morelet.

As a result of the investigations this species is divided into three varieties: **Pinus caribaea** var. **caribaea** (typical) from Cuba, **P. caribaea** var. **hondurensis** from Central America, and **P. caribaea var bahamensis** from the Bahamas.

The most important characteristics of these entities are the following:

PINUS CARIBAEA Morelet var. CARIBAEA (typical)

Needles in fascicles of 3 (rarely 4); cones 5-10 cm. long; seeds with adnate wings (remaining attached). It is found on Isla de Pinos and Pinar del Río, western Cuba, at elevations from 150 to 1150 feet, in tropical climate (annual average temperature 76 - 78ºF) subhumid and humid (annual rainfall 47 - 63 inches), with six months drought; acid soils (pH 4,5 - 6).

PINUS CARIBAEA Morelet var. HONDURENSIS nov. var.

Needles in fascicles of 3, sometimes 4, 5 (and 6 in young trees), cones 6-14 cm. long; seeds with articulate wings (wings become detached), except a low percentage with adnate wings. Occurs on the Atlantic slopes in Central America of British Honduras, Guatemala, Honduras, and Nicaragua, from sea level to 2,800 feet, in tropical or subtropical climate (70 - 81ºF), from subhumid to superhumid (annual rainfall 38 - 140 inches) with a two - six months drought period; acid soils (pH 4 - 6,5).

PINUS CARIBAEA Morelet var. BAHAMENSIS nov. var.

Needles in fascicles of 2 and 3; cones 4-12 cm. long; seeds with articulate wing, rarely adnate. It is found on Bahamas Islands: Grand Bahama, Great Abaco, Andros, New Providence, and Caicos from sea level to 100 feet in tropical climate, (77ºF), subhumid (annual rainfall 30 - 50 inches) with six - seven months drought; alkaline soils (pH 7,5 — 8,5).

En las últimas décadas, se ha despertado un enorme interés por el cultivo de un grupo de pinos, que hasta hace poco se reunían bajo el nombre de *Pinus caribaea* Morelet y que viven naturalmente en el sudeste de los Estados Unidos, Bahamas, Cuba y desde Honduras Británica hasta Nicaragua, por lo general en sitios de poca elevación. Estos pinos aparecen en forma intensiva en los programas de forestación de numerosos países del hemisferio sur, dado su rápido crecimiento y múltiples usos.

La especie mencionada fué dividida por Little y Dorman (1952) en *Pinus elliottii* Engelm. nombre dado al "slash pine" del sudeste de los E. U. A., y *Pinus caribaea* Morelet para los pinos de Cuba, Centroamérica y Bahamas. A pesar de este criterio, muchos forestales consideran al pino continental centroamericano como una entidad diferente del "pino del caribe" de Cuba. En efecto, al cultivar estos pinos en Argentina, se notaron diferencias tanto en su hábito, crecimiento, precocidad, tamaño y forma de las semillas, como en sus exigencias ecológicas. Con tal motivo se resolvió realizar un estudio taxonómico de los pinos del litoral atlántico centroamericano, que posteriormente se extendió a las Bahamas con el objeto de abarcar toda el área geográfica de la especie. Se encontraron algunas diferencias morfológicas entre las poblaciones antedichas comparadas con la forma típica de Cuba, tales como ala de la semilla articulada y hojas de a 2 y 3 por fascículo en las Bahamas, y en Centroamérica ala de la semilla generalmente articulada, conos con gran variación en el tamaño alcanzando hasta 41 cm. de largo. Se observaron además caracteres diferenciales en los conos, hábito, formación de hojas aciculares secundarias en plantas jóvenes, y otros que se detallan en este trabajo.

El ala de la semilla en el género *Pinus*, cuando presente, puede ser: *articulada* cuando se separa fácilmente de la semilla sin quebrarse ni dejar restos en la misma, o *adnata*

cuando no puede ser separada sin ser lastimada o dejar restos en la semilla. Este carácter es considerado de suma importancia por los distintos autores que han estudiado el género. Shaw (1914) considera el ala articulada como más evolucionada, y que esa variación en órgano tan importante como la semilla, sugiere diferencias de géneros, aunque aclara que en *Pinus* se encuentran los dos tipos en especies del mismo grupo. Pilger (1926) lo utiliza para separar la sección *Sula*. Gaussen (1961) considera el ala articulada como un carácter primitivo y el ala adnata como evolucionado.

Concluyendo: Dada la importancia taxonómica que tiene el ala de la semilla y por otros caracteres diferenciales, existen suficientes razones para considerar las poblaciones geográficamente aisladas de *Pinus caribaea* Morelet como entidades diferentes, aunque no merezcan el rango específico. Por lo tanto se subdivide esta especie en tres variedades: *P. caribaea* var. *caribaea* de Cuba (típica); *P. caribaea* var. *hondurensis* de Centroamérica y *P. caribaea* var. *bahamensis* de las Islas Bahamas.

METODO DE TRABAJO

Los estudios realizados sobre esta especie, incluyeron: Observaciones en el campo, recolección de material de herbario, cosecha de semillas, y su posterior cultivo. Se revisó críticamente la bibliografía existente y se solicitó material botánico e informes a distintas instituciones y personas a las cuales se agradece, especialmente al Dr. W. C. Steere del New York Botanical Garden (N.Y.), a la Dra. A. Lourteig del Musée d' Histoire Naturelle de Paris, al Conservator of Forests of British Honduras, Mr. A. C. Frith y colaboradores, y a Mr. C. P. Nielsen de Owens-Illinois of the Bahamas, Limited.

En 1957, Golfari en compañía del Ing. Carlos Negrotti, enviados por Celulosa Argentina S. A., realizaron un viaje por Nicaragua, Honduras, Guatemala, Honduras Británica, y Cuba con el fin de estudiar esta especie en su habitat y recolectar semillas para su siembra en Argentina. En 1960, en ocasión del viaje de estudios de las coníferas latinoamericanas organizado por F.A.O. los autores tuvieron oportunidad de recorrer pinares de esta especie en Honduras, Honduras Británica, Cuba, y Bahamas. Durante este viaje se recogió abundante material que se encuentra depositado en el herbario del Instituto de Botánica (BAB) del Instituto Nacional de Tecnología Agropecuaria (I.N.T.A.) de Buenos Aires.

Con semillas de distinto origen se realizaron cultivos experimentales en Buenos Aires, Delta, Santa Fe, Tucumán y Misiones (Argentina). Las plantas de dichos cultivos se estudiaron comparativamente en distintas etapas de su desarrollo. A estas observaciones se agregaron otras realizadas en Sao Pablo (Brazil) con plantas de mayor edad.

DESCRIPCION DE LA ESPECIE

PINUS CARIBAEA Morelet

Pinus caribaea Morelet, Rev. Hort. Cote d'Or 1:105-107, 1851.

Nombres vulgares: pino del caribe, pino antillano.

Arbol de 8 a 45 m. de altura con diámetro de hasta 100 cm.; *corteza* cuando joven grisácea, rugosa, resquebrajada en surcos longitudinales más o menos profundos, característica que puede mantener cuando adulto o bien puede formar placas grandes, castañas, de surcos poco profundos, lisas, que se descascaran en finas láminas; *yemas* con escamas castañas, sueltas, no resinosas, con flecos blanquecinos; *brotes* del año multinodales, más o menos pruinosos; *hojas* comúnmente de a 3 por fascículo aunque puede tener 2, 4 y 5 por fascículo, de 13 a 33 cm. de largo, de 1 a 1,5 mm. de espesor, rígidas, de borde aserrado con bandas estomáticas en todas las caras, hipodermis biforme, de 2 a 5 hileras, canales resiníferos internos de 2 a 8,

Figura 2. Aspectos de los bosques de Pinus caribaea. A: Pinus caribaea var. caribaea en Consolación del Norte, Provincia de Pinar del Río, Cuba. B: Pinus caribaea var. bahamensis en suelo esquelético desarrollado sobre piedra caliza coralífera. C: Pinus caribaea var. hondurensis cerca de Waspán, Río Coco, Nicaragua.

vainas persistentes de 10 a 16 mm. de largo, castañas claras que oscurecen a la madurez; *flores* masculinas en amentos de 20 a 45 mm. de largo; *conitos* generalmente reflexos; *conos* más o menos asimétricos de 4 a 14 cm. de largo, ovados a oblongos ovados, caedizos aunque pueden quedar abiertos un año o más en la planta, pedicelo curvo de 1 a 1,5 cm. de largo, que puede quedar adherido a la rama o al cono; este abre a la madurez, con escamas abiertas algo reflexas, delgadas, oscuras exceptuando el apófisis que es castaño brillante, con una quilla transversal y un mucrón pequeño que puede estar ligeramente armado; *semillas* de angostamente ovoides a triangulares, con ala castaña membranácea que puede permanecer adherida a la semilla (adnata) o se desprende fácilmente de la misma (articulada).

CLAVE PARA LA DETERMINACION DE LAS VARIEDADES

A. Hojas comúnmente de a 3 por fascículo, a veces más.
   B. Semillas con el ala adnata; hojas de a 3, raro 4; conos de 5 a 10 cm. de largo. Islas de Pinos y Pinar del Río, Cuba.
      1. *P. caribaea* var. *caribaea*
   BB. Semillas con ala articulada con bajo porcentaje de adnata; hojas de a 3, a veces 4 y 5; conos de 6 a 14 cm. de largo. Honduras Británica, Guatemala, Honduras y Nicaragua.
      2. *P. caribaea* var. *hondurensis*

AA. Hojas de a 2 y 3 por fascículo; semillas con ala articulada, raramente adnata; conos de 4 a 12 cm. de largo. Islas Bahamas.
   3. *P. caribaea* var. *bahamensis*

DESCRIPCION DE LAS VARIEDADES

1. *Pinus caribaea* Morelet var. *caribaea* (típica)

Pinus caribaea Morelet, Rev. Hort. Cote d'Or 1:105-107, 1851.

Pinus recurvata Rowlee, Torrey Bot. Club. Bull. 30:107, 1903.

Nombres vulgares: "pino macho" y "pino amarillo" (Cuba), pino caribea de Cuba (América latina).

Arbol de 10 a 25 m. de altura, diámetro hasta 70 cm.; *hojas* comúnmente en grupos de a 3 por fascículo, raramente 4, de 15 a 25 cm. de largo, de 1 a 1,3 mm. de espesor, agudas, con bandas estomáticas en todas las caras, canales resiníferos internos de 3 a 6, hipodermis biforme de 3 a 5 hileras; *vainas* de 10 a 13 mm. de largo, castañas a negruzcas cuando adultas; *flores* masculinas en amentos de 20 a 32 mm.; *conos* ligeramente asimétricos, de 5 a 10 cm. de largo, cónicos cuando cerrados y oblongos cuando abiertos, maduran en el mes de julio y primeros días de agosto; *semillas* angostamente ovoides, el doble de largo que ancho, de 6 mm. de largo, 3 mm. de ancho y 2 mm. de espesor, color gris pardo moteado pardo claro, tegumento débil, el peso promedio es de 14 mgr. (en un kilogramo entran aproximadamente 70 mil semillas), ala membranácea, castaña, que permanece adherida a la semilla; *cotiledones* de 4 a 8, promedio de tres distintas procedencias: 5,71; 5,78 y 5,96. Según Little y Dorman (1954): 5,90 y 5,96.

OBSERVACIONES EN CULTIVO

Las hojas aciculares secundarias aparecen a los 2-3 meses. El crecimiento es lento tanto en el primer como segundo año. En el primer año, la raíz crece más en profundidad que en alto la parte aérea. Contrariamente a la variedad continental, presenta durante los primeros cinco años, gran uniformidad de crecimiento entre los individuos y asimismo una notable resistencia a la sequía. En plantas jóvenes se observan brotes con ramillas amarillentas y hojas con un promedio de menos de 20 cm. de largo.

DISTRIBUCION GEOGRAFICA

En la Isla de Pinos y en la provincia cubana de Pinar del Río, entre 21°40' y 22°50' de latitud norte, en planicies suavemente

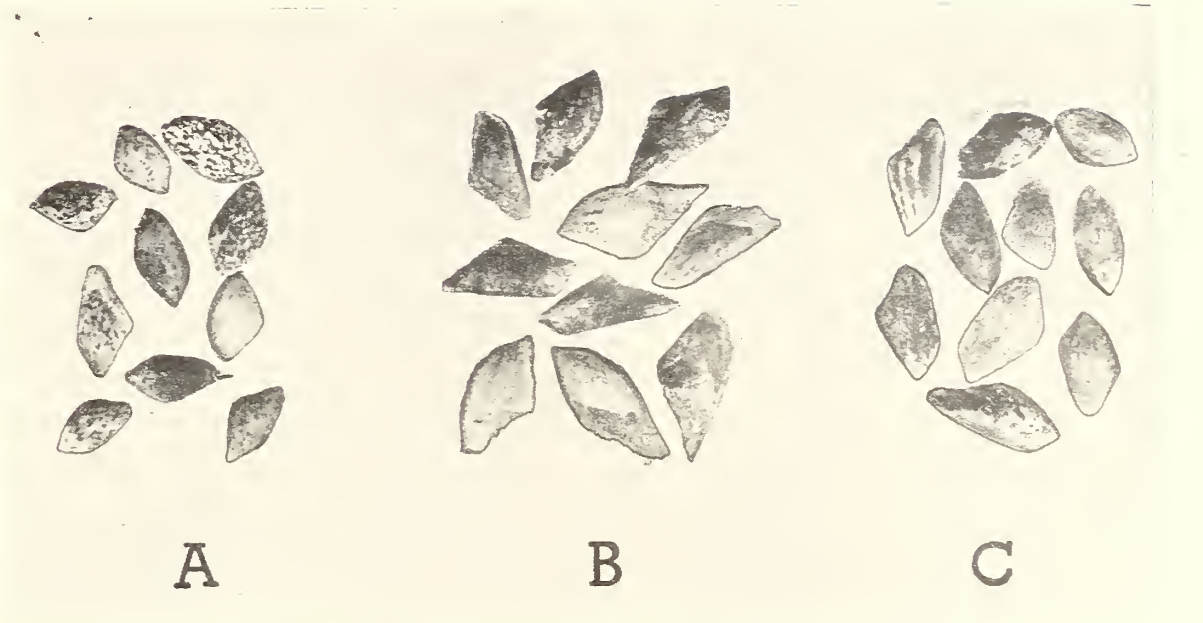

Figura 3. Semillas de Pinus caribaea. A: Pinus caribaea var. bahamensis. B: Pinus caribaea var. caribaea. C: Pinus caribaea var. hondurensis.

onduladas y colinas bajas a una altitud entre 45 y 355 metros. Está asociado, en toda su área, con *Pinus tropicalis* que es más abundante, excepto en Lomas de Cajálbana donde existe un rodal puro.

Vive en clima tropical con temperatura media anual entre 24,5° y 25,5°C con poca variación estacional (22°C media del mes más frío y 28°C media del mes más cálido); 4°C mínima absoluta. Las lluvias, entre 1200 y 1600 mm. anuales, son de tipo periódico, concentrándose el 80% durante el semestre más cálido, de mayo a octubre, siguiendo luego una temporada seca bien definida, de 5 a 6 meses.

Los suelos que pertenecen al grupo de los latosólicos (rojos, pardorojizos y amarillos) se han formado sobre esquistos y areniscas, excepto en Lomas de Cajálbana donde se han desarrollado sobre serpentinas; el drenaje es bueno y su reacción netamente ácida, con pH entre 4,5 y 6.

2. *Pinus caribaea* Morelet var. *hondurensis* nov. var.

Pinus hondurensis Seneclauze, Conif. 126, 1867 (no visto, fide Little y Dorman, U. S. Forest Service Southeastern For. Exp. Sta. No. 36: 15-16, 1954).

Pinus hondurensis Loock, South Africa Forestry Ass. Journ. 18:60, 1949 (Nomen nudum).

Pinus hondurensis Loock[1], Union South Africa Dept. Forestry Bull. 35: 210, 1951.

Nombres vulgares: pitch pine (Honduras Británica, Nicaragua y Honduras); yellow pine, white pine (Honduras Británica); pino de la costa (Honduras); ocote blanco (Guatemala); pino caribea de Honduras (América latina).

1/ Es común encontrar en la literatura forestal el uso del nombre Pinus hondurensis Loock. para denominar a la entidad centroamericana. Sin embargo, esta denominación como ya fuera aclarado por Little y Dorman (1952, 1954) no es válida. La descripción de Loock (1951) segrega el tipo existente en Centroamérica del que habita en los Estados Unidos en lugar de separarlo del tipo de Cuba sobre el cual Morelet (1851) describió la especie. Además, este nombre es sinónimo de un nombre anterior P. hondurensis Seneclauze 1867. Conif. 126, que se refiere a un pino de Honduras con 3 y 4 a veces 5 y 6 hojas por fascículo, siendo el único de los 4 pinos de Honduras (P. caribaea Morelet, P. oocarpa Schiede, P. pseudostrobus Lindl. y P. ayacahuite Ehrenb) en tener este carácter, como fuera observado en cultivo en Argentina sobre plantas jóvenes. Por lo tanto, si bien incompleta, la descripción de Seneclauze corresponde al pino costero y sería el primer nombre específico dado a este pino.

Figura 4. Plantitas de 6 meses. Ninguna presenta estado cespitoso. La flecha indica el nivel del suelo. La escala tiene 5 centímetros. 1. Pinus caribaea var. caribaea. 2. Pinus caribaea var. hondurensis. Nótese la ausencia de hojas aciculares. 3. Pinus caribaea var. bahamensis.

A varietate typica differt foliis ternis interdum quaternis et quinis in fasciculo; strobilis 6 - 14 cm. longus; semina cum ala articulata, raro adnata. Habitat in litore atlantico Americae Mediae.

Difiere de la variedad típica por tener 3 hojas y a veces 4 y 5 por fascículo; conos de 6 a 14 cm. de largo, semillas articuladas, raramente adnata. Habita el litoral atlántico de Centro América continental.

Se designa como tipo el siguiente material: W. Barrett - 77.582 Augustine, 550 m. de altitud, Mountain Pine Ridge, distrito Cayo, Honduras Británica, 5 nov. 1960

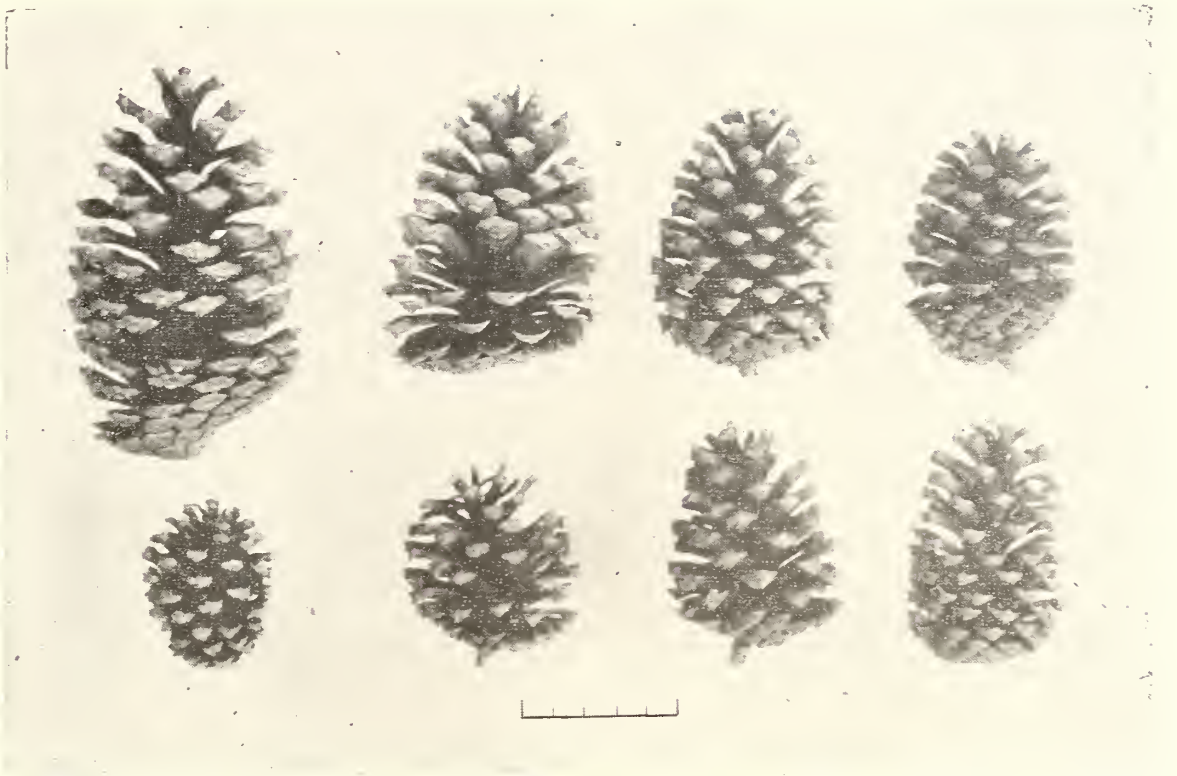

Figura 5. Conos de Pinus caribaea var. hondurensis de Honduras Británica. El grande es de Mountain Pine Ridge y los otros de la planicie costera, Mango Creek y cerca de Blair Atholl. La escala tiene 5 centímetros.

(BAB).

Arbol de 10 a 45 m. de alto, diámetro de hasta 100 cm; *hojas* comúnmente en grupos de a 3 por fascículo, aunque se pueden encontrar de a 4 y 5 (Honduras y Guatemala) y excepcionalmente 2 (Guatemala). En plantas jóvenes los fascículos con 4 y 5 hojas se encuentran con mayor frecuencia que en las adultas, presentándose hasta de 6; largo de las hojas de 13 a 33 cm. (Honduras Británica, 19-27 cm.; Guatemala, 15-33 cm.; Honduras, 18-32 cm.; Nicaragua, 13-24 cm.), espesor de 1 a 1,5 mm., canales resiníferos internos de 2 a 5; *vainas* de 10 a 16 mm. de largo castaño claras a parduzcas nunca oscuro-negruzcas; *flores* masculinas en amentos cilíndricos de 25 a 45 mm.; *conos* oblongos, asimétricos, algo encorvados, de 6 a 14 cm. de largo. Ancho en conos cerrados de 2,8 a 4,5 cm. y en conos abiertos de 6 a 7,5 cm. La madurez de los conos ocurre en la costa durante los meses de junio y julio y en el interior en julio y agosto; *semillas* angostamente ovoides de 6,5 mm. de largo, 3,5 mm. de ancho y 2 mm. de espesor, tegumento algo más fuerte que en la variedad típica, largo algo menor del doble que el ancho, color variable, de pardo claro a castaño y negruzco, algo más oscura que en la típica. En un kilogramo entran de 50 mil a 60 mil semillas. Ala membranácea castaño-oscura, que se desprende fácilmente de la semilla (articulada) exceptuando aproximadamente un 10% que permanece adherida; *cotiledones* de 5 a 9, promedio de dos distintas procedencias: 6,43 y 6,95. Según Little y Dorman (1954): 6,58.

OBSERVACIONES EN CULTIVO

Las hojas aciculares secundarias aparecen entre los 8 y 12 meses, llevando la planta hasta ese entonces las hojas primarias de

color verde claro. Las plantas jóvenes se caracterizan por tener numerosos brotes adventicios en la base del tronco que persisten hasta los 3 ó 4 años. Esta variedad crece durante el primer año más que el doble que la variedad típica. En los almácigos, el crecimiento de la parte aérea al año, es muy superior al crecimiento en largo de la raíz. En plantas de 2 a 5 años, obtenidas de semillas de Guatemala y Honduras Británica se ha observado con frecuencia un porte anormal, que se manifiesta con un rápido crecimiento de hasta 10 m. de altura, sin ramificaciones laterales que en lengua inglesa se denomina "fox tail growth" y ha sido observado también en Sud Africa, Trinidad, y Guayana Británica. Entre esta anormalidad y el crecimiento típico existen todas clases de formas intermedias. En plantas jóvenes se observan brotes con ramillas blanquecinas y hojas de un promedio de 25 cm. de largo.

DISTRIBUCION GEOGRAFICA

Se encuentra en numerosas masas discontinuas y fragmentadas, ubicadas entre 18° (Orange Walk, Honduras Británica) y 12° de latitud norte (Bluefield, Nicaragua), distribuídas en los siguientes países: Honduras Británica (distritos de Orange Walk, Belice, Cayo, Stann Creek, Toledo), Guatemala (departamentos de Petén, Izabal y Alta Verapaz), Honduras (departamentos de Cortés, Santa Bárbara, Yoro, Francisco Morazán, El Paraíso, Olancho y Colón), Nicaragua (comarca de El Cabo y departamento de Zelaya), por lo general a menos de 100 Km. de la costa atlántica, exceptuando algunos pequeños rodales en Honduras, ubicados más cerca del Pacífico. Se lo encuentra desde el nivel del mar, en las llanuras costeras, hasta las colinas y mesetas del interior con una elevación máxima de 850 m. (Honduras y Honduras Británica).

Existen grandes variaciones climáticas dentro de su área. Como extremos se podría citar: la región litoral con clima tropical (temperatura media anual de 24° a 27,2°C con poca variación estacional), lluvias abundantes (de hasta 3500 mm. anuales con un corto período de 2 a 3 meses de sequía), que corresponde a un bosque higrofítico, y la región del interior con clima subtropical (temperatura media anual entre 20° a 24°C, con mayor variación estacional) y lluvias escasas (desde 950 mm. anuales con un largo período de sequía de 6 meses) que corresponde a un bosque xerofítico. Es interesante mencionar que toda su área está libre de heladas, correspondiendo la mínima absoluta, de 2°C, a la región más elevada del interior.

Los suelos, que pertenecen al grupo de los latosólicos (rojos, pardos rojizos y amarillos, se han desarrollado sobre distintas rocas madres como granitos, esquistos, areniscas (Mountain Pine Ridge, Honduras Británica), andesitas (interior de Honduras) y dolomitas (Petén, Guatemala). En la región costera los pinos crecen sobre suelos aluviales, formados por arenas finas a veces limosas (Honduras Británica) o por rodados silíceos y arenas gruesas (Nicaragua). El drenaje de los suelos varía desde bueno en la región colinosa del interior, a deficiente en la costera, debido al escaso desnivel y a la presencia frecuente de un subsuelo arcilloso e impermeable. La reacción de los suelos es ácida, variando el pH entre 6,5 (El Zamorano, Honduras) y 4,3 (Puerto Cabezas, Nicaragua).

Un medio ambiente tan variado hace suponer la existencia de ecotipos de exigencias climáticas y edáficas definidas, que deberán ser tomados en cuenta en los programas de forestación, con el fin de elegir la fuente de semilla más adecuada para cada región. Estas variaciones se hacen evidentes en algunas regiones donde los pobladores reconocen distintos tipos. Por ejemplo en la comarca de El Cabo, Nicaragua, distinguen tres tipos: el "pino de hojas cortas", el "pino de hojas largas" y el "pino bastardo".

En Honduras Británica al analizarse comparativamente la forma costera con la de la

montaña, se han encontrado pequeñas diferencias que no son suficientes para considerarlas entidades morfológicas distintas. En la costa, los conos son más pequeños y el peso y tamaño de la semilla es menor (Stann Creek, 60 mil semillas y Cayo, 50 mil semillas por kilogramo). Indudablemente que este problema merece ser estudiado con mayor detalle, dada la gran importancia forestal de esta entidad y la necesidad de conocer a fondo la amplia gama de variaciones ecológicas. Por otra parte sería interesante determinar si existe introgresión con *P. oocarpa* Schiede, especie que vive en un piso altitudinal superior. En la zona de contacto de ambas especies se encuentran numerosas formas intermedias. Por ejemplo: se han encontrado en Honduras individuos de características que responden a *P. caribaea* Morelet pero con conos persistentes, ovales y hojas delgadas en fascículos de a 4 y 5.

3. *Pinus caribaea* Morelet var. *bahamensis* nov. var.

Pinus bahamensis Griseb. Flora of the British West Indian Isles 503, 1864.
Nombres vulgares: yellow pine, pino de las Bahamas.

A varietate typica differt foliis binis vel ternis in fasciculo; strobilis 4 - 12 cm. longus; semina cum ala articulata, raro adnata. Habitat in Bahamarum insulis.

Difiere de la variedad típica por poseer hojas en número de 2 y 3 por fascículo; conos de 4 a 12 cm; semillas con ala articulada raramente adnata. Habita en las Islas Bahamas.

Se designa como tipo el siguiente material de herbario: L. Golfari - 77.571 New Providence, 6 m. de altitud, Islas Bahamas, 20 nov. 1960 (BAB).

Figura 6. Material tipo. La escala tiene 5 centímetros. A: Pinus caribaea var. hondurensis. Rama con flores masculinas inmaduras. Conito de 1 año y cono maduro. B: Pinus caribaea var. bahamensis. Rama con conos maduros.

Arbol de porte mediano, de 8 a 20 m. de altura y de hasta 50 cm. de diámetro; *corteza* joven grisácea, rugosa, resquebrajada en surcos longitudinales; *yemas* con escamas castañas claras, sueltas con flecos blanquecinos; *brotes* del año multinodales; *hojas* comúnmente de 2 y 3 por fascículo en distinta proporción que varía según las Islas: New Providence 2 y 3; Gran Bahama 2 raro 3; Andros y Abaco 3 raro 2, de 1 a 1,5 mm. de espesor, rígidas de borde aserrado, con bandas estomáticas en todas las caras, hipodermis biforme, de 3 a 4 hileras, canales resiníferos internos de 3 a 7; *vainas* persistentes de 10 a 12 mm. de largo, de escamas castañas amarillentas a pardas; *conos* cónicos a angostamente cilíndricos, ligeramente asimétricos de 4 a 12 cm. de largo, promedio de Gran Bahama 7 cm., New Providence 8 cm., Abaco y Andros 10 cm.; pedicelo curvo de 1 a 2 cm., caedizos, abren a la madurez, escamas abiertas algo reflexas, delgadas, de color rojizo en la parte interna superior, en la inferior oscura casi negruzca, apófisis castaño claro brillante con quilla transversal débil y mucrón con espina débil o nula. Maduran en agosto y setiembre; semillas pequeñas, oscuras de tamaño y forma irregular, de angostas a triangulares, de 5 a 6 mm. de largo y menos de 2 mm. de espesor, el peso promedio es de 14 mgr. (en un kilogramo hay de 68 a 70 mil semillas); ala articulada, muy raramente adnata; cotiledones 4 a 7, promedio 5,25 (semilla de Great Abaco).

No presenta un estado juvenil cespitoso a pesar de vivir en condiciones ecológicas similares a *P. elliottii* var. *densa*. Las plantas jóvenes tienen características de porte, hojas primarias, formación de hojas adultas y crecimiento, intermedio entre *P. caribaea* var. *caribaea* y *P. elliottii* var. *elliottii*. Con esta última tiene estrecho parentesco de la que se diferencia por el menor tamaño de los conos y semillas y la espina débil o ausente de las escamas del cono.

DISTRIBUCION GEOGRAFICA

Habita las Islas Bahamas en dos áreas disyuntas, distanciadas en 600 Km. La primera incluye las islas Grand Bahama, Great Abaco, New Providence y Andros, entre 27 y 23°4' latitud norte. La segunda ocupa las Islas Caicos entre 22 y 21° latitud norte. En todas estas islas crece a menos de 30 m. de altitud sobre el nivel del mar, sobre suelos muy delgados de reacción alcalina (pH 7,5 y 8,5), desarrollados sobre calizas coralíferas.

El clima es netamente tropical con temperatura media anual de 25 a 26°C con poca amplitud térmica entre el mes más frío (22° a 23°C) y el más cálido (28° a 29°C). Las lluvias en las islas del norte alcanzan aproximadamente 1300 mm. anuales, decreciendo en las Islas Caicos hasta 750 mm. Con respecto a su distribución, en las primeras existe un período lluvioso de mayo a octubre, al que sigue una sequía de noviembre hasta abril. En las Islas Caicos las condiciones de sequía se manifiestan más intensamente con un período seco de 7 a 8 meses.

La ubicación geográfica de las Islas Caicos con respecto a Española y Cuba, permitía suponer que los pinos que habitan las primeras, estuviesen emparentados con *P. occidentalis* Sw. (Española) y *P. cubensis* Griseb. (este de Cuba). Sin embargo, el material estudiado de North Caicos y Pine Cay corresponde a *P. caribaea* var. *bahamensis*. Existe en Pine Cay una raza de conos pequeños de 3,5 a 5,5 cm. de largo pero se han eencontrado en la misma isla y North Caicos ejemplares con conos más grandes.

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Key to Mexican Species of Pines

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SUMMARY

An indented key for identification of the 41 species of pines (**Pinus**) native to Mexico is presented in both English and Spanish. It is based upon participation in the FAO Seminar and Study Tour of Latin American Conifers in Mexico in September-October 1960. The nomenclature of Martínez is followed, with the addition of two species and omission of varieties and forms. There are included a brief review of related publications and notes on several names.

RESUMEN

Se presenta en español e inglés una clave indentada para facilitar la identificación de los pinos (**Pinus**) oriundos de México. Se basa sobre la participación en el Seminario y Viaje de Estudio de Coníferas Latinoamericanas en México en septiembre y octubre de 1960. Se sigue la nomenclatura de Martínez con la adición de dos especies y la omisión de las variedades y formas. Se incluyen comentarios breves de algunas de las publicaciones relacionadas y notas sobre varios nombres.

This new key to the species of pines (*Pinus)* native in Mexico is based upon my participation in the FAO Seminar and Study Tour of Latin American Conifers in Mexico in September-October 1960. Prepared by request, this indented key to aid identification should be simpler and easier to follow than the parallel type in use.

In the published report of the above mentioned Mexican tour, I discussed the identification of Mexican pines and compiled for this purpose four tables summarizing the botanical characters of 27 Mexican species of pines, excluding Baja California (6). This key is a synthesis of that information.

Although plant taxonomists have not agreed upon the exact number, Mexico has more species of pines than any other equal area in the world. In two early conservative monographs, both reprinted in recent years, Shaw (10, 11) grouped the Mexican pines into 19 species and 16 varieties.

Martínez (8, 9), of the Instituto Nacional de Biología, Universidad Nacional de México, made the most detailed taxonomic study of the Mexican pines, distinguishing 39 species, 19 varieties, and 8 forms, of these naming 4 species, 15 varieties, and all 8 forms. Loock (7), a South African forester, after a year in Mexico published in English another reference following Martínez's nomenclature. These references in Spanish and English both contain detailed botanical descriptions, numerous illustrations, identical nomenclature, and keys of the parallel type to all the named botanical variations.

Gaussen (4), in the most recent monograph of the genus *Pinus* in the world recorded 48 species from Mexico, including 9 additional species elevated from varieties distinguished by Martínez.

The FAO Seminar and Study Tour of Latin American Conifers (6) agreed to accept in its report the nomenclature of Martínez, which is used by Mexican foresters, especially in distribution of seeds. This FAO tour of about 10,000 kilometers through Mexico presented an unsual opportunity for additional field study of Mexican pines and

for collection of herbarium specimens of 22 species chiefly in the states of Chihuahua, Durango, Jalisco, Michoacán, Oaxaca, and Chiapas.

This key to the 41 species of pines (*Pinus*) in Mexico follows the nomenclature of Martínez (9) and Loock (7), with 2 additions. Omission of varieties and forms should simplify use of the key and identification. These minor variations seldom distinguished by foresters may be found in those references. *Pinus cooperi* Blanco (2, p. 185, fig. 1) has been adopted here to replace *P. lutea* Blanco, a later homonym renamed by its author.

Pinus culminicola Andresen & Beaman (1), a recently described species of pine of the pinyon group, has been added to the key. It is a rare shrub of no commercial value, known only from the timberline at the summit of Cerro Potosí, Nuevo León, in northeastern Mexico.

One additional species, *P. caribaea* Morelet, has been recorded by Standley and Steyermark (12, p. 46) from southern Quintana Roo at the eastern border of Mexico, where it apparently is rare and local. This species was described and illustrated by Loock (7, p. 210) as *P. hondurensis* Loock.

The 11 species of *Pinus* recorded from Baja California are so indicated in the key. With the exception of *P. cembroides*, these are temperate zone species extending from California south into northern Baja California and not native in other parts of Mexico. Records of *P. ponderosa* from Baja California refer to *P. jeffreyi*, according to Duffield and Cumming (3). However, the typical variation of *P. ponderosa* has been reported from Chihuahua.

Mexican pines that occur naturally in adjacent countries have been interpreted conservatively by recent taxonomists. For example, in the United States, Little (5), regarded *P. chihuahuana* as the variety *P. leiophylla* var. *chihuahuana* (Engelm.) Shaw, *P. arizonica* as *P. ponderosa* var. *arizonica* (Engelm.) Shaw, *P. reflexa* as *P. flexilis* var. *reflexa* Engelm., and *P. remorata* as a synonym of *P. muricata* D. Don. However, *P. cembroides* var. *edulis* was accepted as a distinct species, *P. edulis* Engelm.

Standley and Steyermark (12, pp. 48-50, 53-55) in their Flora of Guatemala placed *P. tenuifolia* as a synonym of *P. pseudostrobus* and considered *P. rudis* and *P. hartwegii* to be the same variety, *P. montezumae* var. rudis (Engl.) Shaw.

A few taxonomic groups of Mexican pines included here may not merit specific rank, and further reduction from species to varieties is a possibility. However, the exact rank of each taxonomic group is not of great importance, and complete agreement is unlikely. Also, older valid names may be available to replace certain names proposed in recent years, for example, *P. michoacana*.

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KEY TO MEXICAN SPECIES OF PINES

A. Bracts below needle fascicles not decurrent on twigs; needles with deciduous sheath (persistent sheath in *P. nelsonii*); *needles* with 1 vascular bundle; bark of twigs and branches smooth — Subgenus *Haploxylon*, Soft or White Pines

B. Needles 1-4, rarely 5, short, 2-10 cm. long, sheath deciduous late and incompletely; seeds without wing, large, edible; umbo of cone scales dorsal — Group of *P. cembroides (Pinyons or Piñoneros)*

C. Cones rounded, short, 3-7 cm. long, almost stalkless, needles 2-7 cm. long

D. Seeds less than 15 mm. long, thick-shelled, with oily taste; cones 3-6 cm. long.

E. Needles 3 (also Baja California) — *P. cembroides*

EE. Needles 2 — *P. cembroides* var. *edulis* or *P. edulis*

EEE. Needles 5 — *P. culminicola*

DD. Seeds more than 15 mm. long, thin-shelled, with mealy taste; cones 5-7 cm. long

F. Needles 4 (Baja California) — *P. quadrifolia*

FF. Needles 1 (Baja California) — *P. monophylla*

CC. Cones cylindrical, mostly long, 6-12 cm. long, long-stalked; needles 4-10 cm. long

G. Needles 3, slender; cone stalk straight, slender — *P. pinceana*

GG. Needles appearing as 1, actually 3, very slender, fastened together, with persistent sheath; cone stalk curved and very stout — *P. nelsonii*

BB. Needles 5, 6-15 cm. long, sheath deciduous early and completely; seeds with long or very short wing; umbo of cone scales terminal — Group of *P. ayacahuite*

H. Stomata of needles absent from outer (dorsal) surface, present on inner (ventral) surfaces, cones small to large

I. Cones mostly less than 20 cm. long

J. Cone scales with thin straight apex (apophysis); seeds with long wing — *P. strobus* var. *chiapensis*

JJ. Cone scales with thick apex (apophysis); seeds with very short wing

K. Cone scales with apex short, broadly wedge-shaped — *P. flexilis*

KK. Cone scales with apex long, curved to reflexed, with longitudinal lines — *P. reflexa*

II. Cones 20-40 cm. long — *P. ayacahuite*

HH. Stomata of needles present as whitish lines on all surfaces; cones large, 27-45 cm. long (Baja California) — *P. lambertiana*

AA. Bracts below needle fascicles decurrent on twigs; needles with persistent sheath (deciduous sheath in *P. leiophylla*, *P. chihuahuana*, and *P. lumholtzii*); needles with 2 vascular bundles, usually distinct; bark of twigs and branches usually rough — Subgenus *Pinus* or *Diploxylon*, Hard Pines

L. Needles with deciduous sheath — Group of *P. leiophylla*

M. Needle short, 8-14 cm. long, erect and spreading; cones persistent and open

N. Needles mostly 5, slender — *P. leiophylla*

NN. Needles mostly 3, stout — *P. chihuahuana*

MM. Needles long, 15-30 cm. long, drooping from curved base, stiff, stout; cones deciduous within 1 year — *P. lumholtzii*

LL. Needles with persistent sheath
O. Cones deciduous or persistent less than 1 year, symmetrical; spring shoots uninodal (multinodal in *P. caribaea)* Group Australes
P. Cone scales without prickle or with weak, usually deciduous prickle; cones usually with short stalk
Q. Cones small, less than 8 cm. long Group of *P. teocote*
R. Cones symmetrical, cone scales equal
S. Needles 3, stout *P. teocote*
SS. Needles 3-4, slender *P. herrerai*
RR. Cones usually slighlty oblique; cone scales unequal, usually with protuberance; needles 3-5 *P. lawsonii*
QQ. Cones more than 8 cm. long Group of *P. pseudostrobus*
T. Needles drooping, 5, sometimes 6, 15-33 cm. long; cones 8-10 cm. long
U. Bark of branches and upper trunk smooth gray
V. Needles very slender, 20-28 cm. long *P. tenuifolia*
VV. Needles slender, 17-24 cm. long *P. pseudostrobus*
UU. Bark of upper trunk scaly red; needles slightly stout, 25-33 cm. long, only slightly drooping *P. douglasiana*
TT. Needles erect to spreading Group of *P. montezumae*
W. Cones 23-30 cm. long, cylindrical or oblong; needles 5, sometimes 6, 25-45 cm. long; subtropical, 1,800-2,400 m. altitude *P. michoacana*
WW. Cones less than 20 m. long, conical or ovoid; needles usually less than 25 cm. long
X. Cones brown; needles usually 5 (4-6)
Y. Cones 10-15 cm. long, dark brown; needles 5 (4-6) 15-25 cm. long; subtropical and temperate zones *P. montezumae*
YY. Cones 5-10 cm. long
Z. Needles 5, 5-15 cm. long; cones reddish brown to yellowish brown; temperate zone, 2,400-2,700 m. altitude *P. cooperi (P. lutes)*
ZZ. Needles 5 (4-6), 10-15 (20) cm. long; cones dark brown; high mountains, temperate zone, 2,500-3,400 m. altitude *P. rudis*
XX. Cones very dark, almost black, 6-12 cm. long; needles 3-5, 7-15 cm. long; high mountains, temperate zone to timberline, 3,000-4,000 m. altitude *P. hartwegii*
PP. Cone scales with prickle sharp, stout, persistent; cones stalkless (except *P. caribaea)*, when shedding often leaving several basal scales attached to twig
a. Cones with stalk 1-1.5 cm. long; spring shoots multinodal; needles 3 (4-5) (Quintana Roo) *P. caribaea*
aa. Cones stalkless Group of *P. Ponderosa*
b. Needles very long and spreading to drooping, 30-40 cm. long, 3-5; twigs very stout *P. engelmannii*
bb. Needles less than 30 cm. long; twigs of average diameter

c. Needles gray green, 3; odor of lemon (Baja California) *P. jeffreyi*

cc. Needles green, 2-7; odor of resin

d. Needles 2-3, stout *P. ponderosa*

dd. Needles more numerous, slender

e. Needles 5-3 *P. arizonica*

ee. Needles mostly 6 (5-7) *P. durangensis*

OO. Cones long persistent, more orless oblique or asymmetrical (mostly symmetrical in *P. oocarpa);* spring shoots multinodal (uninodal in *P. oocarpa* and *P. pringlei)*

f. Cones very large and heavy, 25-35 cm. long; needles 3, 15-30 cm. long, very stout (Baja California) *P. coulteri*

ff. Cones less than 16 cm. long; needles various, slender to stout Group Insignes ("Serotinos")

g. Spring shoots uninodal

h. Cones narrowly conic, slightly oblique, reflexed on short stiff stalk; needles 3, 15-25 cm. long *P. pringlei*

hh. Cones egg-shaped, top-shaped, or rounded, long-stalked; needles 3-5, 15-30 cm. long *P. oocarpa*

gg. Spring shoots multinodal (also uninodal in *P. greggii*)

i. Needles short, 3-8 cm. long, 2; cones 3-5 cm. long (Baja California) *P. contorta*

ii. Needles longer, more than 8 cm. long; cones more than 5 cm. long

j. Cones slightly oblique, 6-12 cm. long; cone scales away from twig gradually larger than those next to twig

k. Needles 3, sometimes 4 or 5, slender and drooping, 15-30 cm. long; bark of branches and upper trunk scaly red; twigs rough *P. patula*

kk. Needles 3, erect, 7-10 cm. long; bark of branches and upper trunk smooth gray; twigs smooth *P. greggii*

jj. Cones very oblique; cone scales away from twig abruptly larger than those next to twig (Baja California)

l. Cones 5-8 cm. long; cone scales with very stout spine; needles 2, 6-20 cm. long

m. Cone scales with prominent conical apex (apophysis (Baja California) *P. muricata*

mm. Cone scales with short broad apex (apophysis) (Baja California) *P. remorata*

ll. Cones 7-16 cm. long; cone scales with minute or deciduous prickle; needles 8-16 cm. long

n. Bark of branches and upper trunk smooth, pale brown; needles 3 (Baja California) *P. attenuata*

nn. Bark of branches and upper trunk rough, dark brown; needles 3 or 2 (Baja California) *P. radiata*

CLAVE PARA LAS ESPECIES DE PINOS MEXICANOS

A. Brácteas bajo los fascículos de hojas no decurrentes en las ramitas; hojas o agujas con vaina caediza (vaina persistente en *P. nelsonii);* hojas con 1 haz vascular; corteza de ramitas y ramas lisa — Subgénero *Haploxylon*, Pinos Blandos o Blancos

B. Hojas 1-4, raramente 5, cortas, 2-10 cm. de largo, vaina caediza tarde y no completamente; semillas sin alas, grandes comestibles; umbo de las escamas del cono, dorsal — Grupo de *P. cembroides* (Piñoneros)

C. Conos redondeados, cortos, 3-7 cm. de largo, casi sin pedúnculo; hojas 2-7 cm. de largo

D. Semillas menores de 15 mm. de largo, con cáscara gruesa, con sabor oleaginoso; conos 3-6 cm. de largo

E. Hojas 3 (también en Baja California) — *P. cembroides*

EE. Hojas 2 — *P. cembroides* var. *edulis* o *P. edulis*

EEE. Hojas 5 — *P. culminicola*

DD. Semillas mayores de 15 mm. de largo, con cáscara delgada, con sabor harinoso; conos 5-7 cm. de largo

F. Hojas 4 (Baja California) — *P. quadrifolia*

FF. Hojas 1 (Baja California) — *P. monophylla*

CC. Conos cilíndricos, mayormente largos, 6-12 cm. de largo, con pedúnculo largo; hojas 4-10 cm. de largo

G. Hojas 3, delgadas; cono con pedúnculo recto, delgado — *P. pinceana*

GG. Hojas que parecen como 1, realmente 3, muy delgadas, adheridas juntas, con vaina persistente; cono con pedúnculo curvo y muy grueso — *P. nelsonii*

BB. Hojas 5, 6-15 cm. de largo, vaina caediza temprano y completamente; semillas con ala larga o muy corta; umbo de las escamas del cono, terminal — Grupo de *P. ayacahuite*

H. Estomas de las hojas ausentes en la superficie externa (dorsal), presentes en las superficies internas (ventrales); conos pequeños a grandes

I. Conos generalmente menores de 20 cm. de largo

J. Escamas del cono con ápice (apófisis) delgado, recto; semillas con ala larga — *P. strobus* var. *chiapensis*

JJ. Escamas del cono con ápice (apófisis) grueso; semillas con ala muy corta

K. Escamas del cono con ápice corto, anchamente cuneado — *P. flexilis*

KK. Escamas del cono con ápice largo, curvo a reflejado, con líneas longitudinales — *P. reflexa*

II. Conos 20-40 cm. de largo — *P. ayacahuite*

HH. Estomas de las hojas presentes como líneas blanquecinas en todas las superficies; conos grandes, 27-45 cm. de largo (Baja California) *P. lambertiana*

AA. Brácteas bajo los fascículos de hojas decurrentes en las ramitas; hojas o agujas con vaina persistente (vaina caediza en *P. leiophylla*, *P. chihuahuana* y *P. lumholtzii);* hojas con 2 haces vasculares, generalmente áspera — Subgénero *Pinus* o *Diploxylon*, Pinos Duros

L. Hojas con vaina caediza — Grupo de *P. leiophylla*
M. Hojas cortas, 8-14 cm. de largo, erectas y dispersas; conos persistentes y abiertos
N. Hojas generalmente 5, delgadas — *P. leiophylla*
NN. Hojas generalmente 3, anchas — *P. chihuahuana*
MM. Hojas largas, 15-30 cm. de largo, colgantes de la base curva, tiesas, anchas; conos caedizos dentro de 1 año — *P. lumholtzii*
LL. Hojas con vaina persistente
O. Conos caedizos o persistentes menos de 1 año, simétricos; ramitas del año (retoños) uninodales (multinodales en *P. caribaea)* — Grupo Australes
P. Escamas del cono sin espina o con espinita débil, generalmente caedizas; cono generalmente con pedúnculo corto
Q. Conos pequeños, menos de 8 cm. de largo — Grupo de *P. teocote*
R. Conos simétricos, escamas del cono iguales
S. Hojas 3, anchas — *P. teocote*
SS. Hojas 3-4, delgadas — *P. herrerai*
RR. Conos generalmente un poco oblicuos; escamas del cono desiguales, generalmente con una protuberancia; hojas 3-5 — *P. lawsonii*
QQ. Conos mayores de 8 cm. de largo — Grupo de *P. pseudostrobus*
T. Hojas colgantes, 5, a veces 6, 15-33 cm. de largo; conos 8-10 cm de largo
U. Corteza de ramas y tronco superior lisa y gris
V. Hojas muy delgadas, 20-28 cm. de largo — *P. tenuifolia*
VV. Hojas delgadas, 17-24 cm. de largo — *P. pseudostrobus*
UU. Corteza de ramas y tronco superior con escamas rojizas; hojas levemente anchas, 25-33 cm. de largo, sólo levemente colgantes — *P. douglasiana*
TT. Hojas erectas a dispersas — Grupo de *P. montezumae*
W. Conos 23-30 cm. de largo, cilíndricos u oblongos; hojas 5 a veces 6, 25-45 cm. de largo; subtropical, 1,800-2,400 m de altitud — *P. michoacana*
WW. Conos menores de 20 cm. de largo, cónicos u ovoides; hojas generalmente menos de 25 cm. de largo
X. Conos morenos; hojas generalmente 5 (4-6)
Y. Conos 10-15 cm. de largo, color castaño oscuro; hojas 5 (4-6), 15-25 cm. de largo; zonas subtropicales y templadas — *P. montezumae*
YY. Conos 5-10 cm. de largo
Z. Hojas 5, 5-15 cm. de largo; conos color castaño rojizo a castaño amarillento; zona templada 2,400-2,700 m. de altitud — *P. cooperi* (*P. lutea)*
ZZ. Hojas 5 (4-6), 10-15 (20) cm. de largo; conos color castaño oscuro; montañas altas, zona templada, 2,500-3,400 m. de altitud — *P. rudis*
XX. Conos de color muy oscuro, casi negro, 6-12 cm. de largo; hojas 3-5, 7-15 cm. de largo; montañas altas,

desde la zona templada hasta el límite de los árboles, 3,000-4,000 m. de altitud *P. hartwegii*

PP. Escamas del cono con espina aguda fuerte persistente; conos sin pedúnculo (excepto *P. caribaea)*, cuando caen frecuentemente dejan varias escamas basales adheridas a la ramita Grupo de *P. ponderosa*

a. Conos con pedúnculo de 1-1.5 cm. de largo; ramitas del año (retoños) multinodales; hojas 3 (4-5) (Quintana Roo) *P. caribaea*

aa. Conos sin pedúnculo

b. Hojas muy largas, dispersas a colgantes, 30-40 cm. de largo, 3-5; ramitas muy gruesas *P. engelmannii*

bb. Hojas menores de 30 cm. de largo; ramitas de diámetro corriente

c. Hojas color verde grisáceo, 3; olor de limón (Baja California) *P. jeffreyi*

cc. Hojas verdes, 2-7; olor de resina

d. Hojas 2-3, anchas *P. ponderosa*

dd. Hojas más numerosas, delgadas

e. Hojas 5-3 *P. arizonica*

ee. Hojas generalmente 6 (5-7) *P. durangensis*

OO. Conos persistentes durante varios años, más o menos oblicuos o asimétricos (generalmente simétricos en *P. oocarpa)*: ramitas del año (retoños) multinodales (uninodales en *P. oocarpa* y *P. pringlei)*

f. Conos muy grandes y pesados, 25-35 cm. de largo; hojas 3, 15-30 cm. de largo, muy anchas (Baja California) *P. coulteri*

ff. Conos menores de 16 cm. de largo; hojas varias, delgadas a anchas Grupo Insignes ("Serotinos")

g. Ramitas del año (retoños) uninodales

h. Conos angostamente cónicos, levemente oblicuos reflejados en pedúnculo corto tieso; hojas 3, 15-25 cm. de largo *P. pringlei*

hh. Conos en forma de huevo o de trompo o redondeados, con pedúnculo largo; hojas 3-5, 15-30 cm. de largo *P. oocarpa*

gg. Ramitas del año (retoños) multinodales (también uninodales en *P. greggii)*

i. Hojas cortas, 3-8 cm. de largo, 2; conos 3-5 cm. de largo (Baja California) *P. contorta*

ii. Hojas más largas, mayores de 8 cm. de largo; conos mayores de 5 cm. de largo

j. Conos levemente oblicuos, 6-12 cm. de largo, las escamas lejanas de la ramita son gradualmente más grandes que las próximas a la ramita.

k. Hojas 3, a veces 4 ó 5, delgadas y colgantes 15-30 cm. de largo; la corteza de las ramas y el tronco superior tienen escamas rojas; ramitas ásperas *P. patula*

kk. Hojas 3, erectas, 7-10 cm. de largo; la corteza de las ramas y el tronco superior es lisa, gris; ramitas lisas *P. greggii*

jj. Conos muy oblicuos, las escamas lejanas de la ramita son abruptamente más grandes que las próximas a la ramita

(Baja California)

l. Conos 5-8 cm. de largo; las escamas del cono tienen espina muy gruesa; hojas 2, 6-20 cm. de largo

m. Escamas del cono tienen ápice (apófisis) cónico prominente (Baja California) *P. muricata*

mm. Escamas del cono con ápice (apófisis) corto y ancho (Baja California) *P. remorata*

Conos 7-16 cm. de largo; las escamas del cono tienen espinita diminuta o débil; hojas 8-16 cm. de largo

n. Corteza de las ramas y del tronco superior lisa y color castaño pálido; hojas 3 (Baja California) *P. attenuata*

nn. Corteza de las ramas y del tronco superior áspera y color castaño oscuro; hojas 3 ó 2 (Baja California) *P. radiata*

The Utilization of Teak Thinnings in Trinidad and Tobago[1]

by
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SUMMARY

Teak (**Tectona grandis L**) was introduced into Trinidad in 1913 and a factory producing fencing, fence posts and lumber from small-size teak thinnings is now in operation. The plant has proved to be a financial success, has utilized timber which would otherwise have remained in the forest to rot, has provided employment in a rural area and has done much to publicise the desirable qualities of locally grown teak.

RESUMEN

La teca (**Tectona grandis L**) fué introducida en Trinidad en el año 1913, contando actualmente con 14,000 acres poblados de ésta especie. Durante el 1960, una fábrica operada por el Departamento Forestal, produjo 19 millas de cercas, 28,000 postes y varas, y 250,000 pies tablares de madera aserrada, con una ganancia neta de 19.32 por ciento, incluyendo gastos generales y depreciación.

Además de haber alcanzado un éxito financiero, esta fábrica utilizó madera que de otro modo se hubiera podrido en el bosque, facilitó empleo a la población rural, y ha cooperado grandemente en la divulgación de las buenas cualidades de la teca que se produce localmente.

The area of Trinidad and Tobago amounts to 1863 square miles, the population density is now about 418 per square mile and traditionally, conifers imported from Central and North America have contributed substantially to meeting the timber requirements of the Territory. During the period 1940-1950 there was a decline in the volume of timber imported, but with the increasing availability of foreign lumber from 1950 onwards, the volume of timber landed in Trinidad increased steadily from that year to reach 1.94 million cubic feet in 1960. The pattern of timber consumption during the past 20 years is shown in the following table:

	1938 Cu. Ft.	1948 Cu. Ft.	1958 Cu. Ft.
Local timber	684,200	3,186,000	3,448,100
Imported timber	1,490,300	763,900	1,548,900
Total timber	2,174,500	3,949,900	4,997,000
Population	460,266	600,000	788,600
Annual per capita consumption	4.7	6.6	6.3

The value of imported lumber now exceeds $5 million (W.I.) per annum.

Although 28% of the land surface has been legally constituted as Forest Reserve the yield from the indigenous forest is low and varies between 100 cubic feet and 240 cubic feet of timber per acre when clear felled. Firewood and charcoal is of no real importance since other fuels in the form of electricity, oil and natural gas exist. The effect of the popularity of these fuels on the firewood and charcoal market can be gauged from the volumes of wood sold for fuel or for conversion into charcoal in the years

1/ Presented to the Eighth British Commonwealth Forestry Conference, 1962. Reprinted with grateful acknowledgment to the Government of Trinidad and Tobago.

1949 and 1959. In the former year 2.1 million cubic feet were sold compared with 0.90 in 1959, the decline throughout the period having been remarkably uniform. The immediate problem in Trinidad and Tobago is therefore one of obtaining the maximum amount of timber from existing plantation and forest areas while pursuing a policy of intensive artificial and natural regeneration of those areas worked under a system of yield control by area.

In 1913 teak was introduced into Trinidad by the then Conservator, Mr. C. S. Rodgers. The origin of the seed was Tenasserim in Burma and the species flourished. At the end of 1960 the total acreage under teak amounted to 13,097 acres and expansion was taking place at the rate of 700 acres per annum, this being the maximum annual acreage for which suitable soils are available, based on a rotation of sixty years.

Sample plot data reveal that at the end of the first twenty years of the crop the mean annual increment per acre varies from 130 to 170 cubic feet and that in the 15th to the 20th year the periodic mean annual increment lies between 100 and 130 cubic feet per acre, measurements being made to 3 inch diameter over bark. At the end of the 40th year of the crop, the M.A.I. varies between 90 and 105 cubic feet per acre and between the 35th and 40th year the P.M.A.I. varies between 68 and 75 cubic feet. Assuming a mean annual increment of 120 cubic feet per acre the present gross increment in the teak plantations is therefore in the region of 1,572,000 cubic feet per annum and even allowing for the fact that this figure is based on measurements down to 3" diameter it is evident that, in a timber importing country, such an increment should contribute to meeting the timber demands of the country.

For many years prior to 1947 teak thinnings were marketed as fence posts, as corduroy for road construction and as boards and scantlings when the sizes cut were not large enough to permit conversion on the inserted-tooth circular saws which then existed in the territory.

MANUFACTURE OF CLEFT FENCING

In 1948 the first step was taken in the intensive utilization of small diameter thinnings with the purchase of a machine to make cleft fencing. This hand-operated machine, which was capable of manufacturing fencing in heights of 3 ft., 4 ft. 6 inches, and 6 ft., produced approximately four miles of fencing during the first year and since then production has steadily increased to the present nineteen miles per annum.

Thinnings are made in the earlier years of teak plantations at five yearly intervals and thinnings cut at the age of five years and the tops of thinnings cut at the age of ten years are cleft in the forest by contractors and delivered as fencing pickets to the factory at Brickfield. The costs landed at the factory for 3 ft., 4 ft. 6 inches and 6 ft. pickets are $2.00, $2.40 and $2.60 per one hundred pickets. These costs represent respectively 0.373, 0.448 and 0.485 man days wages ($5.36) per hundred pickets.

The fencing factory now consists of an open shed with a galvanized iron roof 72 ft. by 42 ft. and contains storage space for pickets, a dipping tank for treating the completed fencing and a wire and machine room. Leading from this room is the track along which the machine runs and which is 57 ft. long thus enabling two rolls of fencing, each 25 ft. long to be made by one pass of the machine over the track. The 3 ft. fencing is made by platting a top and a bottom pair of wires around each picket then stapling the wire to the pickets. The 4 ft. 6 inches and 6 ft. fencing is made in a similar way except that the former carries three pairs of platted wires and the latter four pairs of wires. The wire used is galvanized annealed wire of 13½ gauge made up in ½ cwt. coils with an internal diameter of 20 inches. Experience has

shown that it is worth the small extra cost to have the coils wrapped in hessian to prevent damage to the coil during transport.

The number of 25 ft. rolls of 3 ft., 4 ft. 6 inches or 6 ft. fencing made per man day is 8, 7 or 6 rolls respectively. Royalty is credited to the plantation at the rate of 10¢ per cubic foot and after the payment of all overheads (including monthly paid salaries and depreciation) the fencing factory made a net profit during 1960 of $2,480.00 on an expenditure of $22,635.00.

MARKETING OF FENCE POSTS

The sale of teak thinning for use as fence posts has been carried on for many years but the service life of these posts seldom exceeded five years because of termite and fungal attack on the large proportion of sapwood present in young thinnings.

In 1953 a hot-and-cold creosote treatment plant was laid down, the hot tank now being fired with mill waste from the Departmental sawmill built on the same general site. A 50 : 50 mixture of creosote (Specification: B.S. 144: 1954 Type A) and dieseline (Specification: Gas-oil 48: 52 D.1.) is heated to 170° F and air-dried poles immersed in the liquid for four hours. The poles are then transferred to one of the two cold tanks for a minimum of twenty-four hours and absorption of about six pounds of preservative per cubic foot of pole is obtained. Service tests laid down many years ago have shown that under Trinidad conditions this treatment can be expected to give at least fifteen years of service life.

Poles to supply this plant are obtained from the ten year and fifteen year thinnings. The poles are cut and peeled in the forest by contractors and delivered to the mill at an average cost of 5¢ per running foot for poles of 5 ins. top diameter and 6 ft. to 8 ft. long. Poles are stacked in the open for seasoning, although if covered storage were available it would provide faster drying and a more uniform treatment. Royalty is credited to the plantations at the rate of 10¢ per cubic foot and during 1960, 27,174 cubic feet of thinnings was used to supply 28,000 poles varying in length from 6 ft. to 14 feet.

During 1960 a net profit of $9,103.00 was made on an expenditure of $38,791.00.

SAWING OF SMALL SIZE TEAK

In 1955 a Gorwood log-edger designed in the United Kindom for the cutting of softwood thinnings was installed together with a cross cut saw on a site between the fencing factory and the creosoting plant. This type of log-edger had, for several years, been used in the United Kindom for edging softwoods in lengths of 2 feet to 4 feet and it was felt that the machine was capable of dealing with hardwoods thinings up to a diameter of 10 inches if the saws were fitted with inserted teeth. The machine was fitted with two 30" diameter saws each with twenty-eight 2 x 10 x 15/64 pattern teeth, the feed was by a chain fitted with dogs and running along a chain groove in the face of the 16 feet saw table and power was supplied by a 40 H.P. electric motor.

A number of minor modifications became necessary to adapt the saw to hardwood thinnings. It became quickly apparent that the clearance between the saws and the saw frame was insufficient for hardwoods and this difficulty was overcome by increasing the clearance to ¼ inch and re-aligning the riving knives. After a relatively short run saw-dust built up under the feeder chain and lifted the chain above the level of the table thus causing canting of the logs as they passed through the saw. This difficulty was overcome by cutting slots in the chain groove for a distance of five feet back from the saw to permit the saw-dust to fall through the groove. The overload coupling designed originally for the much lower power unit used on softwoods proved to be unduly sensitive and a new and stronger coupling was supplied by the makers.

When these modifications had been completed the saw proved to be satisfactory except that wear on the plain inserted teeth was excessive. An electric jockey-grinder was used to sharpen the teeth and this operation became necessary after cutting about 500 board feet of timber and the total cutting life of the teeth did not exceed 3000 board feet. Chrome-plated teeth were then tried and these gave a cutting life of twice that of the plain teeth.

For the first two years of operation cutting was restricted to the conversion of logs into scantlings of 2 inches by 2 inches to 6 inches by 6 inches. The conversion ratio from such cutting was 5 bd. ft. of scantling per cubic foot of log which was of course very much smaller than that obtained from the sawing of softwoods in the United Kingdom. However, since the minimum length of the scantlings cut was 10 feet compared with the maximum length of 4 feet for softwoods it was hardly surprising that, because of taper and bends over the length of the log, a very much lower conversion ratio was obtained.

Although boxed heart scantlings was the aim, the pith of teak seldom runs true and it was expected that a number of scantlings would be lost through longitudinal splitting where the pith emerged to the surface. In practice however it was found that although the pith emerged to the surface in at least one third of the smaller scantlings cut, loss through splitting was negligible and in the sizes of 4 inches square and upwards it was unusual to find any scantling spoiled by this cause.

The demand for scantlings in lengths of eight and ten feet proved to be very small thus forcing the cutting of twelve and fourteen feet logs. Loss through taper in such sizes becomes excessive unless a market can be found for the heavier slabwood cut from the bottom two-thirds of the logs. For this reason a 26 inch diameter roller feed re-saw fitted with 2½ x 11 x 7/32 chrome-plated inserted teeth was installed to cut the slabwood into 1 inch by 3 inch strips. These strips found an immediate market as nailing-laths, skirting boards, facing and flooring strips. As these products became known, requests were made for a wider variety of sizes ranging from 2 inches by ½ inch to 4 inches by 1 inch. As a result of the increased range of sizes the conversion ratio is now 6 board feet of sawn timber from one cubic foot of log.

Logs to supply the sawmill are obtained from thinnings of fifteen years and upwards and during the year 1960 a quarter of a million board feet of timber was produced. Royalty was credited to the plantations at the rate of 10¢ per cubic foot of log and a net profit of $15,478.00 was made on an expenditure $78,652.00.

GENERAL RESULTS OF OPERATIONS

The utilization of teak thinnings of sizes up to 10 inches top diameter has proved to be a financial success. During 1960 a net profit of $27,061.00 was made on a gross expenditure of $140,078.00. In drawing up the annual statement of accounts care has been taken to include those items which have not been charged directly to the Factory although they are in fact an expenditure incurred in the running of the venture. Thus, such items as salaries of monthly-paid staff, royalty credited to the plantations supplying thinnings, depreciation of machinery, Department transport etc. have all been included in the expenditure of the Factory in order to produce a balance sheet drawn up in accordance with commercial practice.

The financial success of the venture is however only one of the satisfactory results which have emerged from the operations. The existing band and circular sawmills operated by private enterprise are unsuitable for the conversion of small diameter thinnings therefore much of the timber now converted into scantlings and nailing-laths would have

lain in the forest to rot, but for the activities at Brickfield Forest Industries. Then too, in a country with a population density already over four hundred per square mile and still increasing rapidly, the provision of employment is a matter of great concern. The operations at Brickfield have given direct employment to fourteen persons together with a similar or perhaps greater number employed by contractors in the production of pickets and the felling and transportation of poles and logs.

The labour have quickly adapted themselves to the change over from silvicultural operations in the field to the production of fencing, and the operating of the creosote plant and sawmill and this has been made easier by the choice of machinery, which although not of the high speed type, is rugged and requires the minimum of servicing.

The effects of the plant on the local market have been marked. Although teak had been grown in Trinidad for more than forty years before the opening of the sawmill little was known by the public about the advantages of teak over the more popular, but termite susceptible, imported timber. Now there is an increasing demand for teak in the building industry and a greater popular support for the continued expansion of the teak plantations.

Prácticas Usadas en los Viveros de Pinos de Puerto Rico

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RESUMEN

En Río Piedras, Puerto Rico se propagan árboles de pino hondureño, **Pinus caribaea** Morelet sembrando la semilla en cajas sementeras de concreto, las que contienen terreno arenoso lómico previamente fumigado. A las ocho semanas o un poco más tarde, cuando se crea que ha pasado el período de mayor susceptibilidad al ataque del mal de semilleros, se trasplantan las plantitas a bolsas de polietileno de 15 a 20 centímetros de largo por 12 centímetros de ancho. Dichas bolsas han sido llenadas previamente con musgo esfagno que hasta la fecha es el material donde mejor han crecido los arbolitos en la bolsa. Debido a que el musgo esfagno es muy escaso localmente, se están llevando a cabo ensayos con otros materiales tales como aserrín, vermiculita y harina de cachipa de coco. El uso de tierra se considera indeseable debido al mayor peso de la tierra y a otras dificultades que se discuten en el artículo.

Este artículo describe la siembra de la semilla en los semilleros incluyendo las prácticas para controlar el mal de los semilleros, los yerbajos y otros plagas. También describe el método de trasplante a las bolsas incluyendo abonamiento, la inoculación con micorrizas y otras prácticas usadas en la producción de las plantas hasta que están listas para la plantación.

SUMMARY

The practices used in an experimental nursery in Puerto Rico to raise potted seedlings of pine, mostly Honduras pine, **Pinus caribaea** Morelet are described.

The most common method is to sow the pine seed during November in concrete seedbeds 40-60 cms. high by 1.2 meters wide. The seed is sown over a fine sand or a sandy loam soil in beds covered with removable frames of wood and a fine wire mesh covered with a plastic film. This material keeps the rain off protecting the young seedlings from the heavy showers but allows the light to pass through.

Before sowing, the seed is soaked in water for 24 hours or stratified 1 to 2 months at a temperature of about 5ºC (40ºF).

The seedbed is treated prior to sowing with methyl bromide or Sodium N-Methyl ditiocarbonate (Vapam) to reduce damping-off, weeds, and nematode damage.

Small seedlings are transplanted to polyethelene bags 15 and 20 cms. (6 to 9 inches) long by 12 cms. (4 3/4 inches) wide. Seedlings are inoculated with a pinch of mycorrhizal material at time of transplanting. Of all potting materials tested sphagnum moss is the most adequate because of its lightness, ease of transportation, lack of damage to the seedlings from accidental falling of the pots, and superior growth and thriftiness when compared to plain or mixed soil. Due to scarcity of sphagnum moss other materials such as vermiculite, coco peat, and sawdust are being tested. Growth in vermiculite is satisfactory but the material is expensive. Survival in pure sawdust fertilized with 20-20-20 soluble chemical fertilizer is very satisfactory, but growth is slow and seedlings are chlorotic as compared to the other materials tested.

After transplanting seedlings are shaded for several weeks before being exposed to full sunlight. Seedlings are 25-30 cms. (10-12 inches) tall and ready for planting at 8-9 months from sowing.

A variation of the above technique still in the experimental stage is sowing the seed direct in the pots. Seeds in moss and vermiculite suffered heavy losses from damping-off, but survival obtained from sowing seed direct to pots filled with year-old sawdust was very high. Research is continuing on the use of vermiculite, sawdust, and coco peat (ground coconut husk).

INTRODUCCION

La plantación de pinos se ha intensificado recientemente en varios países tropicales. Distintos países están ensayando procedimientos para la producción de plántulas. En Puerto Rico durante los últimos tres años hemos obtenido datos que pueden ser de interés para otros países de condiciones semejantes. Por lo tanto, hemos creído conveniente describir la propagación de arbolitos de pino según se ejecuta en un pequeño vivero forestal en el Instituto de Dasonomía Tropical en Río Piedras, Puerto Rico.

Para que este trabajo no se extienda demasiado no hemos descrito las operaciones en mucho detalle. A aquellos que interesen una descripción un poco más detallada de las prácticas realizadas en viveros de pino en Latinoamérica les sugerimos consultar el artículo titulado "Procedimiento para Pequeños Viveros Forestales en Chile" por Jay H. Hardee (1956). Este artículo describe las prácticas en viveros en una escala factible para los países latinoamericanos. Muchos de los viveros de pino en Estados Unidos de Norte América, especialmente en el sur, están altamente mecanizados y funcionan en una escala de enormes proporciones.

Las prácticas seguidas en Puerto Rico y en otras áreas tropicales incluyen el trasplante a cajas y a receptáculos, macetas o envases mientras que las prácticas descritas en los viveros de Chile y de otros países de las zonas templadas se basan en el trasplante a raíz desnuda. En estos últimos países las plantas son criadas muy juntas en plantabandas, eras o tablones y se arrancan a raíz desnuda al tiempo de la plantación.

En Puerto Rico la propagación de los arbolitos de pino se ha hecho a base de trasplante en receptáculos, mayormente bolsitas de polietileno. Los ensayos (Briscoe 1960, 1962) demuestran que a menudo la supervivencia de las plantitas trasplantadas a raíz desnuda es baja. Además, muchas de las plantas que sobreviven, sufren un período de estancamiento lo cual es muy indeseable en el medio tropical donde los pinos están sometidos a una fuerte competencia de los yerbajos, especialmente durante el primer año después de plantados.

En otros países tropicales se sigue la misma práctica de plantación utilizando diversas modalidades pero siempre a base de que la plántula lleva una porción de tierra adherida a las raíces. De este modo se asegura una supervivencia satisfactoria.

En Africa y en muchas de las anteriores colonias o territorios del Imperio Británico, se utiliza el sistema de semilleros en cajas de madera. La semilla se siembra en cajones en hileras que permiten una distancia que fluctúa entre 4 y 5 o hasta 7½ centímetros para producir entre 25 y 49 plántulas dependiendo del tamaño de la caja. FAO (1956) describe en detalle dicho método. Chalmers (1958) describe una técnica semejante usada en los viveros de la isla de Trinidad. Durante el año 1959 observamos la técnica en los viveros de Trinidad cuando estaban adaptando el sistema de cajas utilizado en Africa para producir unos 25 arbolitos por caja a una distancia de 5 centímetros.

Raets (1961) publicó datos de crecimiento de distintas especies latifoliadas y de pinos, que se trasplantaron y crecieron en tres tipos de envases distintos utilizando tierra mezclada.

La práctica de propagación de pinos en Puerto Rico que se intensificó después del año 1959 nos ha inducido a descartar la tierra y las mezclas de tierra para llenar las bolsas por las razones que explicamos más adelante. Además, se usa exclusivamente la bolsa de tela plástica de 20 centímetros de largo por 12 centímetros de ancho y también un tamaño más pequeño de 15 centímetros de largo la cual ocupa menos espacio y es más fácil de transportar. Este tipo de envase se adapta mejor a nuestras condiciones de trabajo, incluyendo escasez y alto costo de mano de obra; es más económico y además

Figura 1. Vivero experimental en Río Piedras. Al fondo las cajas sementeras de concreto con sombra provisional y usadas temporeramente para albergar las plantitas recién trasplantadas a bolsas. Al frente plántulas de un año listas para plantar.

se obtiene una supervivencia muy alta en la plantación de pinos al campo.

PRACTICAS UTILIZADAS AL CRIAR LAS PLANTAS

DESCRIPCION DEL VIVERO

Los ensayos, objeto de este trabajo, se han realizado en un pequeño vivero experimental (figura 1) localizado en Río Piedras, Puerto Rico. El clima es tropical con una temperatura medio anual de 25°C (77.8°F) y un promedio anual de lluvia de 1854 mm. Los meses de febrero y marzo son secos con un promedio de lluvia de 83.8 mm. La capacidad de producción anual es de 15 a 20 mil plantas. El vivero dispone de una caseta con techo plástico translúcido y de varias cajas semilleras construídas de bloques de concreto y provistas de sombra artificial, además del espacio necesario para acomodar las plantas después de trasplantadas a los envases.

LA SEMILLA

En el Instituto se propaga gran variedad de pinos procedentes de climas tropicales, subtropicales y templados pero la especie predominante es el pino de Honduras (*Pinus caribaea* Morelet), oriundo de las montañas de Honduras Británica. El certificado de origen indica un peso de 15 gramos para 1000 semillas, lo que equivale a unas 66,700 semillas por kilo (30,300 semillas por libra). Dicho documento especifica una capacidad germinativa de 90 a 95 por ciento en semilla fresca. Sin embargo, nuestras pruebas de germinación han dado entre 50 y 60 por ciento usando semilla fresca y 40 por ciento en el caso de semilla que había sido conservada bajo refrigeración 5°C (40°F) durante tres años. Quiere decir que la reducción en la germinación de este lote de semilla al cabo de tres años de almacenaje al frío fué solamente de cerca de 10 por ciento.

EL SEMILLERO

El semillero consiste de unas cajas sementeras con las paredes de concreto o de bloques de concreto, de 40 a 60 centímetros de alto para facilitar el trabajo de los obreros. El interior de la caja es de 1.2 metros

Figura 2. Caja sementera usada para albergar plantitas recién trasplantadas a bolsas de tela plástica. La tela metálica plástica da protección contra los aguaceros fuertes y permite la exposición a la luz solar.

de ancho. En dicha caja se pone una camada de 45 a 60 centímetros de piedra en bloque sobre la cual se coloca otra camada de 15 a 20 centímetros de arena gruesa. El medio donde se riega la semilla consiste de una capa de arena fina o de terreno arenoso lómico de 15 a 20 centímetros de espesor. Según muestra la figura 2 se erige sombra consistente de planchas removibles de zinc o de material plástico. Dichas planchas sobresalen algo sobre el exterior de la caja para proteger el semillero de los aguaceros fuertes. El material más satisfactorio usado para proveer protección es una tela metálica fina cubierta por una película de material plástico transparente. Este material evita que la lluvia caiga sobre el semillero pero permite el paso de la luz. Es preferible regar artificialmente la cantidad de agua que se crea necesaria y proteger el semillero de los aguaceros fuertes y períodos de lluvia prolongados.

La germinación de la semilla puede hacerse sobre una gran variedad de materiales tales como musgo esfagno, vermiculita, aserrín, además de suelo, aunque en la práctica mayormente se utiliza arena fina o suelo lómico arenoso. Estos últimos generalmente son muy bien drenados y tienen poca materia orgánica y se consideran más libres de la infección del mal de los semilleros (damping-off). En Trinidad riegan la semilla sobre una capa de 12 pulgadas de arena fina lavada y las cubren con una capa de guijarros finos. Así se mantiene un nivel relativamente bajo de humedad y se cree que ésto contribuye a que en este tipo de material la incidencia del mal de semilleros sea insignificante. Al usar musgo esfagno como medio para germinación de la semilla hemos notado una alta incidencia del mal de semillero por lo cual su uso no parece recomendable.

EPOCA DE LA SIEMBRA

En Trinidad consideran los meses de noviembre y diciembre los más propios para la siembra de la semilla. Así los arbolitos se desarrollan durante la época fresca y seca del invierno y están listos para la plantación al iniciarse las lluvias fuertes en el verano Nuestra experiencia en Puerto Rico nos lleva a la misma conclusión. Preferimos plantar

árboles grandes de 25 a 30 centímetros (10 a 12 pulgadas) o más. Para alcanzar este tamaño es necesario regar la semilla como ocho meses antes de la época de plantar.

Otra razón, quizá de tanto o mayor peso, es que si se riega la semilla tarde en febrero o marzo no solamente estarán las plántulas pequeñas al tiempo de la plantación, sino que el tiempo seco de vientos constantes durante el mes de marzo aparentemente causa pérdidas casi completas en las plantitas recién plantadas o muy jóvenes. Esto ha ocurrido bajo las condiciones de Río Piedras a poca elevación sobre el nivel del mar. En otro vivero ubicado en las montañas donde predomina una nubosidad casi contínua, donde el aire es más fresco y la humedad posiblemente más alta, no se ha observado dicha pérdida durante el mes de marzo. Sin embargo, es posible que en gran parte del área montañosa menos húmeda y más expuesta a los vientos, las pérdidas sean comparables a las habidas en Río Piedras.

TRATAMIENTOS ESPECIALES

Estratificación. La semilla procedente de Honduras Británica es espolvoreada en su lugar de origen con Hexacloruro de Benzeno para protegerla del ataque de los insectos. Tan pronto se recibe la semilla se conserva en un refrigerador a temperaturas de 1-3°C (33° - 36°F). También hemos encontrado muy conveniente someter la semilla de 4 a 8 semanas al proceso conocido como estratificación. Por este proceso la semilla próxima a sembrarse se sumerge en agua durante 24 horas al cabo de lo cual se distribuye en una camada fina sobre una bandeja. Sobre la semilla se pone un pedazo de tela de bayeta y sobre ésta se deposita una camada de musgo fino, vermiculita u otro material absorbente por el estilo. Dicho material se mantiene húmedo y a la vez mantiene la semilla saturada. La temperatura se mantiene alrededor de 3°C (36°F). La semilla debe sembrarse el mismo día que se saca del refrigerador. La germinación de la semilla sometida a este procedimiento es mucho más alta durante las primeras dos o tres semanas después de la siembra. Esto quiere decir que la germinación se acelera. Aunque la estratificación de la semilla no aumenta la germinación total, la germinación pronta y uniforme constituye una ventaja.

REMOJO

En caso de que la estratificación no sea posible es muy aconsejable, especialmente tratándose de semillas que han estado almacenadas por algún tiempo, remojarlas en agua (el volumen del agua debe ser varias veces mayor que el de las semillas). En el caso de pino de Honduras se consiguen resultados satisfactorios con inmersión por solo 24 horas. Como las semillas remojadas se pegan entre sí y dificultan algo la siembra, conviene secarlas al aire durante un corto período antes de sembrarlas.

DESINFECCION DE LA SEMILLA POR MEDIO DE POLVOS FUNGICIDAS

Algunos investigadores recomiendan mezclar la semilla con polvos fungicidas de manera que la semilla quede cubierta con una película del fungicida en polvo inmediatamente antes de la siembra. Otros investigadores no han encontrado ventaja alguna en esta práctica. Desde luego, solamente pruebas controladas con y sin el uso de distintos fungicidas durante distintos períodos y condiciones pueden demostrar la ventaja de tal procedimiento. En limitadas ocasiones hemos tratado la semilla con los fungicidas a mano, en este caso Fermate y Compuesto A de cobre, pero no hemos realizado pruebas controladas que demuestren el éxito de dicha práctica por lo que carecemos de criterio en relación a su valor real y a las condiciones en que debe usarse, si es que su uso es en sí aconsejable. Comprendemos que debido a lo fácil y económico de llevarlo a la práctica, valdría la pena realizar estudios para investigar su valor real en la defensa contra tales enfermedades como el mal de los semilleros que tantas pérdidas causa.

SIEMBRA DE LA SEMILLA

Dominio del mal de semilleros. La siembra de la semilla hasta la fecha la hemos hecho mayormente en cajas sementeras de cemento (figura 2).

El material que hasta la fecha consideramos más propio para regar la semilla, tratándose de lotes grandes, es un suelo lómico arenoso previamente fumigado. El suelo lómico que usamos tiene un pH que fluctúa entre 5 y 5.5. Este pH denota un suelo fuertemente ácido. En la propagación de pinos ésto constituye una ventaja presumiblemente por su efecto sobre la incidencia del mal de semilleros. La literatura hace resaltar el hecho de que en un suelo ácido la incidencia y ataque del mal de semilleros es mínima por lo que en algunos viveros acostumbran añadir substancias químicas para aumentar la ácidez. Es probable, por lo tanto, que la lozanía de las plantas que crecen en el suelo lómico arenoso, se deba en gran parte a su alto grado de acidez. Las dos primeras pulgadas de este suelo se mezclan con aserrín de madera o vermiculita, lo cual evita la desecación excesiva de este suelo arenoso y la formación de una costra dura en la superficie.

Entre los materiales fumigantes se ha usado el bromuro de metilo (Dowfume) aplicado bajo una tela plástica a razón de 1 a 2 libras del gas por aproximadamente nueve metros cuadrados (100 pies cuadrados) de superficie. R. H. Segall y L. López-Matos (1956) encontraron que en Puerto Rico el bromuro de metilo usado como fumigante resultó más efectivo en el dominio del mal de semilleros de tabaco que los otros fungicidas utilizados tales como el Compuesto A de cobre. También demostraron que el bromuro de metilo tiene cualidades herbicidas por lo cual el semillero se mantiene libre de yerbajos. Como solo se requiere una aplicación antes de la siembra, resulta más conveniente que otros fungicidas que requieren aplicaciones repetidas.

Desde luego, tratándose del mal de los semilleros que resulta ser muy variable y que a veces no responde a ningún patrón fijo en su reacción a distintas condiciones, es de esperar que la efectividad de cualquier tratamiento varíe contínuamente con cambios en el tiempo, en los materiales usados, entre las distintas localizaciones de los viveros, etc., pero el dominio de los yerbajos justifica en sí el tratamiento. También el hecho de que se utilizan áreas bastante reducidas facilita el uso de este fumigante.

También se usa otro fumigante como Vapam (Sodium N-Methyl ditiocarbonate) que se aplica en una solución de agua. El Vapam tiene también propiedades herbicidas (reduce la invasión de yerbajos en el área tratada). No tenemos criterio sobre cual de los dos es más efectivo en la práctica aunque el bromuro de metilo generalmente se considera lo más efectivo hasta la fecha. El hecho de que la aplicación del Vapam no requiere una cubierta o tela plástica facilita su uso cuando es necesario tratar áreas más extensas.

USO DE SUBSTANCIAS NEMATOCIDAS

Hansbrough y Hollis (1957) demostraron en varias comparaciones con distintos fumigantes en viveros en Homer, Louisiana, U.S.A. que la fumigación del suelo con substancias que tenían propiedades nematocidas produjo árboles de pino loblolly (*P. taeda*) más vigorosos y de mayor crecimiento que en las parcelas testigos. Esto lo atribuyen ellos a la marcada reducción en la población de nemátodos parasíticos. Algunas especies de nemátodos fueron eliminadas de las parcelas tratadas durante la mayor parte del período en que los arbolitos crecieron en dichas parcelas. Según dichos investigadores, los resultados parecen indicar que en las parcelas testigos el ataque de los nemátodos era la causa de la reducción marcada en el crecimiento de los arbolitos de pino. Ambos el metilo de bromuro (Dowfume) y el Vapam poseen también propiedades nematocidas.

La semilla que haya recibido tratamientos, bien sea de remojo o de estratificación, se siembra en las cajas sementeras al cabo de por lo menos una semana después de haber quitado la tela plástica para permitir aeración del suelo y el escape del exceso de gas fumigante.

SIEMBRA

La semilla generalmente se riega en surquitos llanos poco más profundos que el diámetro de la semilla. Cuando se usa semilla fresca, y si el propósito es trasplantar prontamente después de la germinación, se siembra la semilla en surquitos a una pulgada de separación. La semilla se coloca en un chorro corrido de manera que no hay separación entre las semillas en el surquito. Si el arbolito ha de permanecer más tiempo en el semillero entonces se riega la semilla a mayor distancia.

TRASPLANTE

En Puerto Rico nunca hemos utilizado cajas para trasplantar y desarrollar los arbolitos de pino según se usan en el sistema de Africa y de los territorios británicos. Consideramos que las cajas son difíciles de manejar en el vivero e incómodas para transportar al campo y dentro de las áreas a repoblar. Muchas de estas áreas son poco accesibles y de topografía accidentada lo cual dificultaría aún más el uso de las cajas.

Aquí dependemos exclusivamente de bolsas de polietileno porque éstas han probado ser baratas, fáciles de obtener en grandes cantidades y muy manuables en el vivero a la vez que producen plantas excelentes. Las bolsas tienen de 15 a 23 cms. (6 a 9 pulgadas) de largo por 12 cms. (4¾ pulgadas) de ancho. Ahora usamos mayormente las de 15 cms. de largo porque ello representa gran economía en el llenado de las bolsas y en la transportación. Las plantitas se pueden trasplantar tan pronto germinan, pero generalmente el trasplante principia a las tres o cuatro semanas después de la siembra. Algunos viveristas argumentan que mientras más pronto se haga el trasplante mejor porque el arranque y el trasplante de una plántula recién germinada son más fáciles, más rápidos y tan seguros como los de una plántula que haya desarrollado la raíz principal. Por otro lado, algunos viveristas temiendo hacer el trasplante mientras las plantitas están tiernas y todavía susceptibles al mal de los semilleros, prefieren darles un cuidado esmerado y protección en el semillero y trasplantar cuando las plantitas estén ya endurecidas y posiblemente libres del ataque del mal, no antes de las siete u ocho semanas. Trasplantes hechos hasta las 12 semanas de la siembra han dado una supervivencia prácticamente perfecta. Hemos observado que las plantitas que se exponen a pleno sol pronto se endurecen, especialmente el tallito lo que posiblemente las hace más resistentes al mal.

Se han hecho pruebas consistentes en pregerminar la semilla manteniendo un puñado de semillas humedecidas dentro de una bolsa de material plástico. Tan pronto brota la radícula de la semilla ésta se saca de la bolsa que hacía de semillero y se trasplanta a la bolsita o al envase en cuestión. Este es un método que desde luego, ahorra el uso de la caja sementera y ahorra trabajo aunque siempre es necesario darle el cuidado esmerado a la plantita que crece en el envase.

SIEMBRA DIRECTA DE LA SEMILLA A LA BOLSA

Llevando el sistema de no usar semilleros o cajas sementeras más lejos aún, estamos realizando pruebas sembrando una o dos semillas (de acuerdo con la calidad de la semilla) directamente al envase (bolsa plástica) o una semilla ya pregerminada según se describe en el párrafo anterior. Las pruebas realizadas de siembra directa (usando semilla ya sometida al proceso de estratificación) demuestran una germinación rápida y cuando se siembran dos semillas por bolsa, un 64 a 84 por ciento de las bolsas ha producido una o dos plantitas. En el caso de haber dos plantitas posiblemente es necesario trasplantar una de las dos a las bolsas donde no

ocurre germinación. Desde luego, este sistema economiza y elimina el uso de la caja sementera y el trasplante de plantitas.

Si se siembra semilla pregerminada en las bolsas entonces se evita casi por completo el tener que resembrar en las bolsas sin plantas o trasplantar cuando hay más de una planta.

Si el ataque del mal de semilleros es mínimo o ninguno se nos ocurre que la siembra directa a las bolsas simplifica enormemente el proceso de los viveros de pino. No sabemos hasta que punto sería necesario fumigar tales materiales como el musgo que utilizamos para llenar las bolsas. Esto es, y como explicaremos más adelante, un sistema intensivo donde no se utiliza tierra, ni hay que preparar sementeras, ni eras, ni es necesario el trasplante. El mayor trabajo y lo cual es enteramente mecánico, es llenar las bolsitas. Durante el pasado año la siembra de las semillas en bolsas que contenían musgo esfagno ha resultado en una mortalidad muy alta, hasta de un 65 por ciento mientras que cuando las bolsitas se llenaron con aserrín la mortalidad fué mucho menor. La semilla, preferiblemente ya germinada, se deposita encima y se cubre ligeramente con los materiales ya indicados. El resto del trabajo consiste en el riego de agua cuando sea necesario. Desde luego, cuando los árboles alcanzan el tamaño necesario para la plantación es cuestion de colocar las bolsas en bateas para cargar en el camión. En estas mismas bateas se llevan al sitio de la plantación.

Queremos hacer hincapié en el hecho de que la siembra de semillas directamente al envase está todavía en estado de prueba. El método más practicado, es el ya descrito de germinar en arena o suelo arenoso y trasplantar preferiblemente las plantas ya endurecidas a las bolsas.

DIFERENTES MATERIALES UTILIZADOS PARA EL CRECIMIENTO DE LOS PINOS EN BOLSAS

Desde el inicio de los trabajos de propagación de pinos nos dimos cuenta de que el crecimiento de los pinos usando la tierra para llenar las bolsas presentaba varios inconvenientes como sigue: Muchos de los suelos que se preparan en los viveros mezclando diversas proporciones de tierra, mantillo, desperdicios orgánicos, arena, etc. no resultan convenientes debido a dificultades en usar las debidas proporciones de los distintos ingredientes. Algunos de los ingredientes escasean o hay que obtenerlos desde una distancia considerable. A veces los desperdicios vegetales crean problemas por estar infestados de yerbajos, introducir plagas de insectos y posiblemente enfermedades.

Uno de los diversos problemas que pueden surgir lo ilustra el uso de los desechos obtenidos de la elaboración de caña de azúcar. Aunque esta sustancia se considera de gran utilidad como enmienda orgánica, tiene un alto contenido de cal. Su uso continuado aumenta la alcalinidad de manera que los suelos que habían recibido esta enmienda a menudo tienen un pH de 8 lo cual se considera poco favorable para el crecimiento de los pinos. Otras dificultades semejantes y difíciles de prever pueden ocurrir con el uso de otras enmiendas.

Sin embargo, quizás la mayor desventaja, es que la tierra es pesada y por lo tanto, dificulta la transportación de las plantas a grandes distancias tratándose especialmente de grandes cantidades de árboles. Mientras una bolsa de 20 centímetros de largo por 12 centímetros de ancho llena de tierra arcillosa pesa 900 gramos (2 libras), la misma bolsa llena de musgo esfagno pesa 198 gramos (7 onzas). El uso de tierra presenta otras dificultades serias. En algunos tipos de suelos las macetas se secan más rápidamente y las plantas sufren más al transportarse a grandes distancias. Por el contrario, si las macetas se humedecen demasiado a menudo se rompen al tiempo de quitarles el plástico para plantar el árbol. También las macetas llenas de tierra se rompen al caerse accidentalmente. Usando musgo, por el contrario, no es necesario preocuparse mucho porque este

material conserva la humedad maravillosamente y las macetas siempre se conservan húmedas. Como es un material fibroso, las raíces de los árboles se entrelazan de manera que la maceta es prácticamente imposible de romper. En la manipulación de los arbolitos en bolsas con musgo acostumbramos tirarlos a veces a una distancia de varios metros sin que la maceta sufra en lo más mínimo

La siguiente información describe el desarrollo de pino hondureño usando diferentes materiales para llenar las bolsas (Marrero 1961).

"El suelo de vivero mezclado tuvo una supervivencia más pobre, solo 5 por ciento, seguido por el suelo Catalina arcilloso fertilizado, con 45 por ciento. Los tres tratamientos restantes tuvieron una supervivencia alta.

Los arbolitos que crecieron en musgo tenían aproximadamente dos veces la altura de los arbolitos que crecieron en suelo y eran 23 por ciento más altos que los que crecieron en la mezcla de suelo arenoso y de vermiculita. La altura promedio al cabo de 6 meses después del trasplante, o sea al estar listos para plantarse, mostró diferencias parecidas. El promedio de altura de los arbolitos en musgo, y en la mezcla de suelo arenoso y vermiculita era estadísticamente superior al de los arbolitos en suelo Catalina arcilloso. Los arbolitos en terreno Catalina arcilloso fertilizado crecieron más rápidamente que los arbolitos en terreno arcilloso sin fertilizar. Sin embargo, la diferencia aparente entre los arbolitos en musgo y los arbolitos en la mezcla de terreno arenoso y vermiculita no fué estadísticamente significativa.

El examen de las raíces demostró que las raíces de los pinos crecieron mucho mejor en el musgo y en la mezcla de vermiculita que en los otros medios. Las raíces eran más numerosas, más largas y más gruesas. También el desarrollo de la micorriza se notaba más abundante en el musgo y en la mezcla de vermiculita que en el caso del suelo arcilloso donde el desarrollo de la micorriza era aparentemente mucho más pobre. El suelo arcilloso en una bolsa pequeña de polietileno se vuelve muy compacto, lo que aparentemente reduce el crecimiento de las raíces de pino y de la micorriza."

Tabla 1. Supervivencia y altura de los arbolitos de pino después del trasplante.

MATERIALES	pH	% Supervivencia a 3 meses	Altura, cms. 3 meses	Altura, cms. 6 meses	Anotaciones
Suelo de vivero mezclado	8.0	5	10.2	—	vigor bajo
Suelo Catalina arcilloso sin fertilizar	6.5	80	8.1	11.2	vigor bajo
Suelo Catalina arcilloso, fertilizado	6.5	45	8.9	17.5	vigor bajo
Suelo arenoso lómico y vermiculita	5.5	95	14.5	21.8	muy vigoroso
Musgo esfagno		90	17.8	29.2	muy vigoroso superior a todos

INOCULACION CON MICORRIZAS

Briscoe (1960) ha descrito la introducción y el uso de micorrizas en relación con el cultivo de pinos en Puerto Rico. Las micorrizas utilizadas en este vivero provienen mayormente de una introducción de mantillo obtenido debajo de un rodal de pino de Virginia (*P. virginiana* Mill.) en el estado de Maryland, Estados Unidos, realizada durante el año 1959. Una pequeña porción (lo que se puede retener entre dos dedos) de material orgánico se aplicó alrededor de las raíces de la plantita al tiempo del trasplante a la bolsa. Posteriormente arbolitos así inoculados se plantaron a lo largo de una era o tablón que contiene terreno arenoso lómico. Esta era

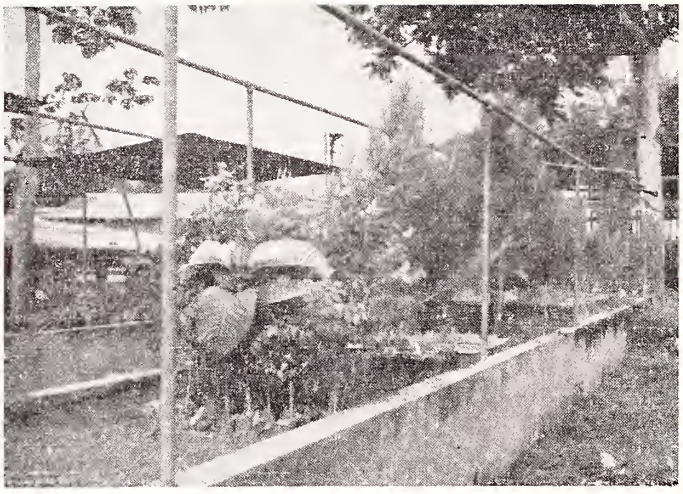

Figura 3. Almáciga que contiene terreno inoculado y donde se mantienen algunos árboles de pinos cuyas raíces estimulan el crecimiento de las micorrizas. Nótese la armazón que sostiene un techo de planchas de zinc para proveer protección a las plantitas. La cubierta más baja y liviana de tela metálica plástica ilustrada en la Fig. 2 se considera más eficiente y cómoda.

(figura 3) se ha utilizado desde entonces para proporcionar tierra inoculada. Quiere decir que la inoculación de algunos miles de arbolitos se hizo directamente con el material introducido de los Estados Unidos porque no teníamos suficiente material derivado de los pocos árboles mayores que anteriormente habían sido inoculados en octubre de 1955 con material proveniente de rodales de pino loblolly (*P. taeda* L.) y pino shortleaf (*P. echinata* Mill.) en el estado de Carolina del Norte. Subsiguientemente se ha obtenido material para inoculaciones proveniente de la era ilustrada en la figura 3 y de pequeñas plantaciones. En la actualidad existe abundancia de micorrizas en las diversas plantaciones de dos años de edad distribuídas por toda la isla.

En síntesis, el sistema que utilizamos para inocular los arbolitos es ponerle una pizca de tierra alrededor de las raíces al trasplantar el arbolito a la bolsa cuando éste ya tiene de unas 7 a 8 semanas o más, contando desde la siembra de la semilla. Entonces consideramos que ya el arbolito se ha endurecido suficiente para resistir el ataque del mal de semilleros. Se recordará que los arbolitos han crecido en un semillero el cual ha sido esterilizado por fumigación y por lo tanto, rodeado de un ambiente relativamente libre de organismos patógenos. Al inocular con tierra llena de hongos es posible contaminar a la vez con los hongos que producen el mal de semilleros. De ahí que preferimos trasplantar los arbolitos cuando ya creemos que ha pasado el peligro de infección. En el caso de que se siembre la semilla directamente a la bolsa se puede esperar que los arboiltos alcancen el estado descrito para hacer la inoculación que consistirá en depositar una pizca de tierra al lado del arbolito cubriéndola ligeramente con la tierra o el material contenido en la bolsa. En nuestro caso ésto ha sido suficiente para que se efectue la inoculación satisfactoriamente.

ABONAMIENTO

Como ya indicamos, no utilizamos tierra a excepción de terreno lómico arcilloso ácido en el semillero. Este terreno es bajo en contenido orgánico y en fertilidad. En este caso acostumbramos hacer una aplicación de abono

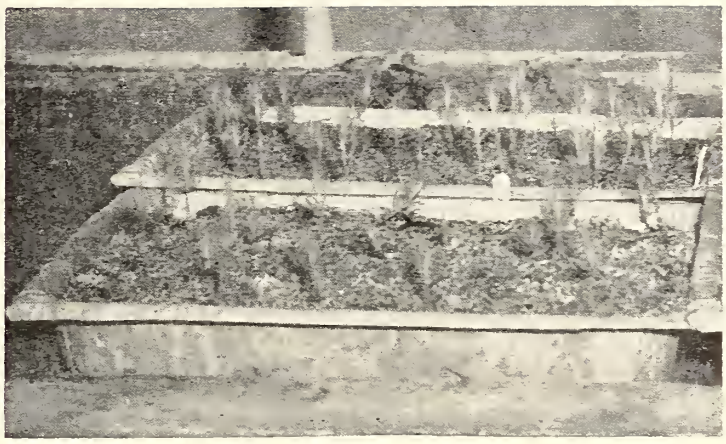

Figura 4. Pequeñas cajas sementeras de metal. Dichas cajas también se utilizan para transportar las plantas enmacetadas al campo.

químico completo fórmula 5-10-10 mezclándolo con tierra antes de la fumigación. La cantidad a aplicar no debe ser excesiva porque podría ser perjudicial. El abono se aplica a razón de una onza por cada dos pies cuadrados o aproximadamente 3 libras por cada 9 metros cuadrados (100 pies cuadrados) de semillero.

En la práctica el abonamiento se realiza mayormente a los arbolitos después de trasplantados en las bolsas o en el caso de siembra directa a la bolsa, generalmente después de la germinación. Para abonar las plantitas cuando ya están en las bolsas se usan fórmulas especiales de alta concentración altamente solubles en agua y que contienen de 18 a 20 unidades por cada uno de los tres principales elementos N P K. Este abono se disuelve en agua a razón de una cucharada por galón de agua. Como la época más crítica es de los 2 a los 4 meses, las aplicaciones se hacen a intervalos de 2 semanas o sea 4 aplicaciones entre el segundo y el cuarto mes. Después de los 4 meses los arbolitos así fertilizados generalmente continuan creciendo a entera satisfacción. Si todavía hubiere arbolitos de color amarillento se puede continuar el uso del abono hasta que los arbolitos se tornen color verde oscuro.

También hemos notado que cuando los arbolitos crecen en musgo esfagno las necesidades de abonamiento son menores que cuando crecen en materiales estériles como el aserrín, posiblemente porque el musgo suple nutrientes que no se encuentran en los demás materiales. Sabemos de muchos lotes de arbolitos en musgo esfagno que no han recibido ningún abono y han desarrollado satisfactoriamente. Sin embargo, en pruebas experimentales en que usamos aserrín fresco los arbolitos desarrollan amarillos y requieren abonamiento para un desarrollo satisfactorio y aún así el desarrollo es muy inferior a cuando se usaron otros materiales tales como musgo esfagno, vermiculita pura y harina de cachipa de coco (coco peat).

Después de trasplantar los arbolitos a las bolsas se dejan a media sombra por varias semanas hasta que se consideren prendidos. Entonces se reduce la sombra gradualmente hasta dejarlos a pleno sol. Para este tiempo los arbolitos en sus envases deben mudarse a las eras o tablones expuestos a pleno sol donde permanecerán hasta que estuvieran listos para llevar al campo.

Durante este período, si el tiempo es seco, sería necesario regar agua lo que se puede hacer con los medios de que se disponga. El método de riego aéreo, aunque inicialmente más costoso, se puede operar con el mínimo

Figura 5. Plantación de Pino hondureño (P. caribaea) al cabo de dos años de plantada. La plantación muestra gran variación en el tipo de las plantas.

de personal. Su uso es más conveniente mientras mayor es el área a regar. Debido a que el diámetro de las bolsas es pequeño y el material plástico es impermeable, se deberá tener cuidado de que el chorro de agua caiga verticalmente y moje la base de los arbolitos, porque el agua que cae sobre los lados de las bolsas se desliza y no penetra dentro.

A menos que los tablones o eras donde se colocan los envases hubieran sido fumigados o tratados con yerbicidas, los yerbajos crecerán en medio de los envases lo que necesitaría cambiar los envases o bolsas de sitio para destruir los yerbajos. Se ha encontrado que dichas eras pueden mantenerse libres de yerbajos si se fumigan con Vapam como una semana antes de colocar los envases. Dentro de la bolsa o envase crecen pocos yerbajos si se utiliza musgo, vermiculita o aserrín. El aserrín, posiblemente debido a la falta de nutrientes, se conserva libre de yerbajos. En caso de usar tierra en los envases ésta debe fumigarse antes de sembrar o trasplantar los arbolitos porque de lo contrario el arbolito se verá rodeado de yerbajos mientras todavía está muy pequeño. En Río Piedras las gramíneas y la verdolaga (Portulaca) son especialmente comunes. Naturalmente, el uso de abonos orgánicos sin fumigar aumenta enormemente la cantidad de yerbajos.

Bajo las condiciones de este vivero el problema de los yerbajos es mínimo aunque siempre es inevitable desyerbar a mano varias veces, pero no constituye una operación de importancia. Los alrededores, los bordes del vivero y las sangrías se tratan ocasionalmente con un yerbicida de contacto, lo cual mantiene los yerbajos bajo control.

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The Breeding of Pine (Pinus Caribaea Mor.) and Teak (Tectona Grandis L.) in Trinidad - Some Early Observations[1]

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SUMMARY

The success of teak and pine plantations in Trinidad has recently led the Forest Department to the view that it is more desirable to concentrate on the improvement of these two species than extend trials of new exotic species. Factors considered in the selection of teak and pine plus-trees are outlined. Of several methods of vegetative propagation tried, air-layering proved best for pine, and budding for teak. Clonal trials have been started for both species to test the genotype of the selected plus-trees. While this evaluation is underway, it is proposed to use the material as seed orchards. Plants are being raised from seed collected from open pollinated plus-trees for use in progeny trials. The timber of locally grown pine is now being studied at the Commonwealth Forestry Institute, Oxford.

RESUMEN

El éxito obtenido en Trinidad con las plantaciones de teca y pino han hecho que el Departamento Forestal haya decidido que es más aconsejable prestar mayor atención al mejoramiento de éstas dos especies que el ampliar ensayos de nuevas especies exóticas. Se describen los factores a considerar en la selección de árboles superiores de teca y pino. De los varios métodos de propagación vegetativa experimentados, el de acodos aéreos resultó ser el mejor para el pino y el de injertos de escudete para la teca. Se han comenzado experimentos de clones con ambas especies para probar el genotipo de los árboles superiores. Mientras se lleva a cabo este estudio, se proyecta usar el material como huertos de árboles para semillas. Se están cultivando arbolitos de semillas recolectadas de árboles superiores polinizados abiertamente para utilizarlos en ensayos de progenie. La madera de pinos producidos localmente está ahora bajo estudio en el "Commonwealth Forestry Institute", Oxford.

INTRODUCTION

In 1959, the Trinidad and Tobago Forest Department embarked on a forest tree breeding project to include, initially, the two most important plantation species, pine (*Pinus caribaea* Mor.) and teak (*Tectona grandis* L.). The project was prompted by a number of considerations. Trinidad is a small island (1,864 sq. miles) with a high population density (418 per square mile). At present, 45% of the land area is under forest and 28% is proclaimed Forest Reserve. Over the last ten years a rapid rise in the standard of living has led to much new building, an increase in the per capita wood consumption and eventually no doubt a greater increase in the pressure on land to meet the demands of agriculture and a rapidly expanding economy. Simultaneously, efforts are being made to produce more timber locally and to reduce the quantity imported. In 1960, timber imports totalled W.I. $5,152,000.00 (one W.I. dollar = 4/2 Sterling), which accounted for 34% of the total consumption.

1/ Presented to the Eighth British Commonwealth Forestry Conference, 1962. Reprinted with grateful acknowledgment to the Government of Trinidad and Tobago.

Every effort is necessary therefore, to ensure the maximum volume production/acre. Present silvicultural and management techniques are such that further modifications are unlikely to achieve any appreciable increase in yield. There is considerable variation in the form and vigour of the existing pine and teak crops. The mounting evidence from countries such as Denmark and the United States, with nearly thirty years of tree breeding experience indicates that the formation of seed orchards for the production of improved strains of pine and teak seed will result in a substantial increase in the quality and quantity of the intermediate and final yield of these crops.

Like other countries over the last thirty years, Trinidad has undertaken trials of many exotic species. At least fifty species have been introduced and it may be argued that others are worth trying. However the outstanding success of teak and pine after 49 and 14 years respectively has recently led the Department to change its policy with regard to exotics. The search for new exotics will for the present, virtually cease in favour of concentrating on the improvement of the two species which are known to thrive under local conditions and for which recent estimates show there is approximately 60,000 acres of land suitable for pine and 42,000 acres suitable for teak. To effect a major improvement in these two species, a tree breeding programme was started in mid 1959 and the following work has been undertaken to date.

TEAK

PLUS-TREE SELECTION

The basis of the breeding programme is the selection from existing plantations of the most outstanding individuals, to which the term 'plus-tree' is generally applied. Plus-trees are selected on the basis of their phenotypic characteristics and are used as the source of material in future breeding work. Teak was introduced to Trinidad by C. S. Rogers, the first Conservator, in 1913. For the first two or three years, seed was received from Tenasserim in Burma, after which seed was collected locally. Apart from a 0.14-acre experimental plot established in 1937 with seed from Travancore in India, no other teak seed has been introduced to Trinidad. It is of interest to note that the Indian strain is far inferior in form and vigour. At the end of 1961 there were 14,000 acres of plantations. Selection of plus-trees is made in stands which are at least twenty years old, by which time they have been thinned from 1210 trees/acre to about 120 trees/acre on the normal five years thinning cycle. There are almost 3,000 acres of teak over 20 years old and approximately 60% of this area has been inspected for plus-trees. Selection is usually made when the trees are in leaf and, if possible, in flower. The main criteria in selection are:

(a) at least forty feet of unforked stem
(b) vigour
(c) a straight cylindrical bole with a minimum of fluting and epicormic shoots
(d) good flowering ability.

The only single factor that would prevent selection as a plus-tree would be (a). After selection, total height, height to the first fork and the length of clear bole is measured with a Spiegel Relascope. The tree is girthed at 4 ft. 3 ins. and given a painted breast-height band and a plus-tree number. Notes are made on fluting, epicormics, type of crown and flowering habit. Total height and girth at breast height (g.b.h.) are measured at the end of each growing season. Of the 96 trees provisionally selected, 65 were rejected following subsequent inspections and close comparisons. The number of plus-trees now being propagated is thirty-one.

VEGETATIVE PROPAGATION

A small trial of air-layers on young teak coppice proved unsuccessful and in 1959 effort was concentrated on rooting teak cuttings. Cuttings were obtained by climbing

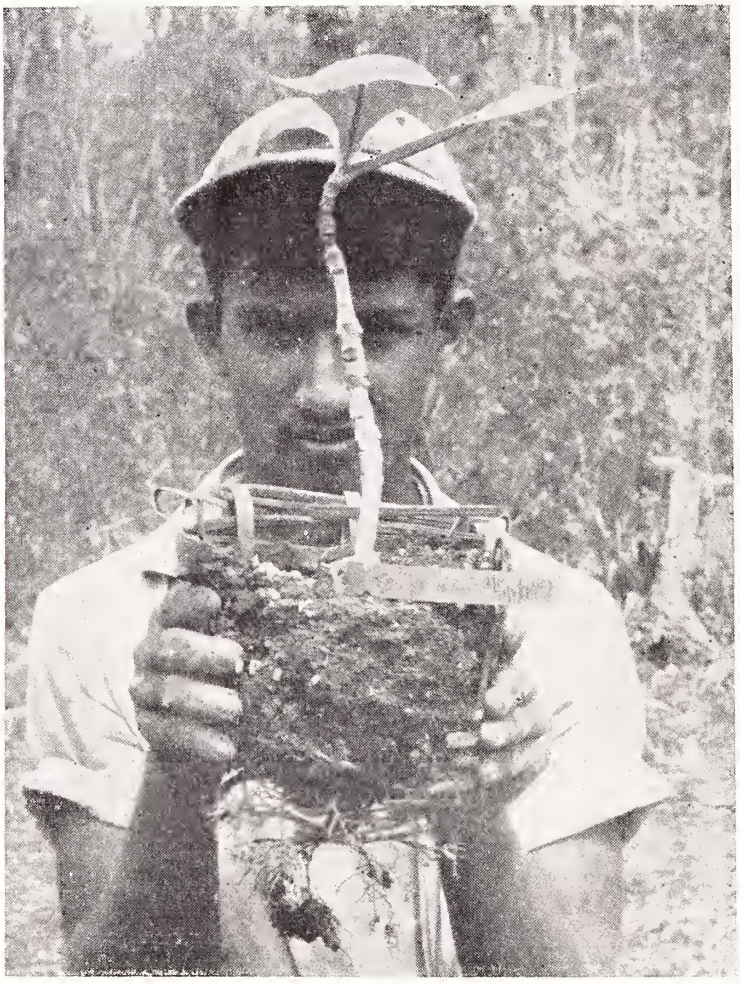

Figure 1. Rooted teak cutting one year old. Note bamboo basket container.

into the crowns of plus-trees, initially about six weeks before flushing and thereafter at monthly intervals up to the middle of the growing season. One or two branches were cut off and from these, cuttings 9-12 ins. long with terminal buds were removed. They were stored in polythene bags until placed in the propagation bin, usually withing 48 hours. Transplanting losses were considerably reduced by preparing cuttings in individual bamboo baskets instead of in a large bed. The baskets had the potting soil surrounding a central 1½ ins. diameter core of the desired rooting medium. A number of rooting media were tried: sand, sawdust, vermiculite, coconut fibre, coconut fibre dust, moss and ordinary soil. The best results were obtained using a slightly coarse sawdust. A dip hormone treatment was tried with some cuttings using indolebutyric acid at concentrations of 0.8g and 1.2g per 100 mls. of 50% alcohol. Rooting success has been consistently better in cuttings not treated with hormone. Those treated did not appear to have more roots nor were the roots more vigorous. There was no obvious difference in the response to the different concentrations. When potted, the cuttings were placed in a closed-type propagation bin having polythene-covered lids. Saran netting was erected over the bin to provide some shade. The cuttings were watered twice daily from a crude built-in

Figure 2. Budded teak seedling. Left: Three weeks after budding. Right: Three months after budding. Note stub remaining of original seedling.

spraying system that could be operated without raising the lids. In very hot weather the lids and outside walls were hosed several times a day. Within a few days the cuttings began to flush. It was essential to maintain a high humidity without watering to excess and thus waterlogging the soil in the baskets. Callous rapidly formed around the cut edge but waterlogging, probably through reducing the aeration, appeared to inhibit the formation of roots. Rooting success was closely linked with the time the cuttings were removed from the tree. In 1960 with cuttings taken on April 16th rooting success was 47% with hormone, 57% without hormone; with cuttings taken on May 17th it was 33% and 36% respectively; cuttings taken on July 26th and August 18th failed to root. In 1960 the teak flushed naturally during the latter half of May. When roots showed through the basket, (12 to 20 weeks) the cuttings were transferred to another bin for a gradual hardening-off period lasting 2-3 weeks after which they were kept in the open.

In November 1959, Dr. C. Syrach Larsen and Mr. M. Keiding from the Arboretum, Horsholm, Denmark, toured the Trinidad teak plantations. On their advice the budding of teak was tried. In 1959 and 1960 small trials were made in addition to the cutting programme, with good results. In 1961 budding replaced cuttings as the chief means

of vegetatively propagating teak. Requiring much less attention though a more skilled operator, budding has given a higher average percentage success than cuttings. Reference should be made to the article on teak budding by Keiding and Sa-ard Boonkird (2). In Trinidad, shield budding with a T incision has been found preferable to the "forkert" method described in the above paper. The ideal time to bud is a period 2-3 weeks befor the wet season proper starts, when the stock and the buds on the trees are in an ideal condition. Buds are obtained as with cuttings. Parts of the branches bearing obviously fresh buds are cut into 6 ins. lengths and stored in polythene bags. The same evening bud shields are prepared for budding the next day. If material is available two buds are grafted to each stock to allow for failures. Budding is done as low as possible on the stem, the bark thickness being the limiting factor. Resinite grafting tape had been found to be more suitable than budding tape because of the thick stems encountered amongst vigorous one year old teak. Budding in wet weather has not been successful. In this respect, raffia binding might be better since moisture is trapped under the grafting tape and this probably hastens the deterioration of the bud. After binding the bud, a large leaf is wrapped round that part of the stock to afford some protection against drying out. Inspection every two or three days is advisable to avoid confusion between the introduced bud and those arising, very close to it, from the stock. After 5-7 days, it i usually obvious if a bud has taken. If it has been successful the stock is cut back 12 inches above the bud about 14 days after budding. Budding success has varied from clone to clone. During the ideal period mentioned above, over 50% success was obtained in seven clones, the best being 86%. Budding with partly flushed buds has been a failure. Budding near the end of the growing season when resting buds have been formed has averaged 11% success in a trial of 60 buds. With practice, a good speed can be attained. The writer and one workman completed 118 buddings in one day, the buds being prepared the previous night.

A small field trial of cleft and side grafts was not successful. Obtaining material for vegetative propagation from the top of tall plus-trees poses a number of problems. In an attempt to overcome these a number of plus-trees were wounded with an axe round the base, above and below soil level, in the hope that 'coppice growth' would be induced but so far, no success has been obtained.

CLONAL TRIAL

The evaluation of individual plus-trees used in the breeding programme is being made by propagating each as a clone and comparing the clones in a clonal trial. This gives an indication of the respective genotypes but may give little information on their breeding value. This can be assessed by means of progeny trials. A five-acre site has been cleared in an area of natural forest four miles from the nearest teak plantataion. The clearing had to be done in two stages, thus a part of the area was planted with teak stumps at 15 x 15 ft. in 1960 and these were budded at the start of the 1961 growing season. The rest of the area was planted with stumps in 1961 for budding in 1962. The layout will be in the form of a 7 x 7 balanced lattice.

A considerable number of buds were made in 1961 on year-old plants in the nursery and these plants will be cut back and transplanted to the clonal trial site in 1962. It is convenient to bud on nursery plants but it is probably best in the long run to plant stumps at the required spacing on the clonal trial site one year before budding. It is a useful precaution to plant two stumps a foot apart at each planting spot in case one fails or is not big enough to bud.

The growth of some budded plants in the clonal trial during the first 8 months long growing season has been extraordinary, some being over 13 ft. tall. Rooted cuttings which

Figure 3. Teak 3 years old. On left: No flowers. On right: Note dead terminal and pair of growing buds immediately below, which will almost certainly yield a forked stem.

had been in pots for a year were transplanted on the same site. They were much slower to get away but over the same two-year period most have grown 6-8 ft. A noticeable characteristic of all except two of the clones propagated to date is the smooth surface and less serrated edge of the leaves compared with leaves of a similar age on the stock. No propagules have flowered in their first growing season, neither have any of the buddings and cuttings made in 1959 and 1960, that is, after two growing seasons.

EARLY FLOWERING

In Trinidad it is not unusual to find teak flowering at three or four years of age. Plantations are normally flowering en masse at the age of five or six, though some trees have not flowered at ten years and even later. It has been observed that flowering of the leading shoot in many instances leads to the forking of the stem and this phenomenon is discussed in a paper by K. Gram and C. Syrach Larsen (1). Under Trinidad conditions, the height growth of teak averages 5-6 ft. per year over the first ten years (sample plot data). Thus it is obvious that early flowering of the leading shoot can cause a considerable reduction in the length of unforked stem. Occasionally, flowering occurs only on side branches, the leader growing on unaffected. In 1960 twelve flowering trees were marked in a three years old plantation. Flowering occurred on the leading shoot of eleven trees and on the side branches of the twelfth tree. Twelve non-flowering control trees were also selected. Inspection in 1961 showed that ten of the former had forked; the crown of the eleventh was obscured. The branch flowerer had not forked. Of the non-flowerers, one had forked. Other observations indicate that flowering of the leader does not always result in forking. When the terminal flower shoot dies the pair of buds immediately below may flush, growing up vertically and equally to form a fork. On occasions, one bud does not flush or may flush and subsequently die back after growing a few inches. In this case, a bud from the next pair frequently adopts a vertical habit and this results in a definite fork. Sometimes only one bud develops and this branch takes over as a single leading shoot; subsequent diameter growth obscures any sign of flowering at that point of stem. Early flowering is thus a most important characteristic, especially if it is genetically controlled, hence the stringent height qualification in selecting plus trees. One early flowerer has been propagated by budding but no propagule has flowered after two years Open pollinated seed has been collected from a number of early flowerers in order to study the progeny. Investigations into the age, type, prevalence and hereditability of flowering and forking are being extended.

BUDDING — SCION/ROOTSTOCK RELATIONSHIP

An effort has been made to raise twelve rootstock clones on to which a number of selected clones will be budded to investigate the effect of the rootstock on the growth of the scion. In 1960, twelve vigorous one year old stump plants were cut back and each divided longitudinally into two and transplanted. This was repeated early in 1961 giving four 'daughter' rootstocks. A third division resulted in heavy losses. Another attempt will be made using 2 or 3 years old rootstocks. Raising suitable clones by cuttings will also be employed.

PROGENY TESTING

Seed has been collected from a number of open pollinated plus-trees. Observations following the sowing of this seed have revealed wide differences in the germination period. This will be studied further. The plants raised will be planted out in replicated trials in 1962.

PINE

Pinus caribaea Mor. was introduced to Trinidad in 1948 using seed from British Honduras. A number of experimental plots were established in various parts of the island between 1948 and 1956. By that time, techniques were sufficiently developed to permit plantations to be formed as a routine silvicultural operation. In 1961 five hundred acres of pine was planted and it is hoped to increase the annual acreage by one hundred and fifty acres until the maximum permissible acreage of two thousand acres per annum is reached.

PLUS-TREE SELECTION

Selection is confined to trees over five years of age. By this time, the majority

Figure 4. Plus-tree of Pinus caribaea. Note straight stem and small, wide-angled branches.

have passed the typical juvenile stage during which some trees exhibit exceptional vigour which is not maintained subsequently. The Department is aware that selection so early and from such a small population possesses inherent dangers but it is believed that selection and breeding from young crops is better than no selection at all. Once the technique has been perfected selection and breeding from progressively older crops will be continuous. The criteria applied during selection are:

(a) straight unforked stem
(b) vigour

(c) light regular branching, with a wide branch angle
(d) good seed bearing.

The only single factor at present debarring a tree from selection would be a forked stem. In one half-acre sample plot, 9% of the trees had forked below twenty feet at eight years. Forking is more prevalent in some years than others, suggesting a link with seed collection. Vigour is important but trees below the average plus-tree gbh (about 35 ins. at ten years) have been selected in view of other characteristics. One plus-tree, growing isolated in a garden and undoubtedly the largest pine in Trinidad, had a gbh of 52 ins. and a total height of 65 ft. at twelve years. Another of the same age, growing in competition with second growth hardwoods, has a fine straight stem and exceptionally light branching. It had a gbh of 28½ ins. and total height 65 ft. and the reduced gbh may well be due to the effect of environment.

Variation in branching habit is considerable but two recognisable types are preferred:

(a) a very light, branch form giving several regularly spaced whorls a year,
(b) a heavier type of branch with fewer whorls a year and fewer branches in the whorl.

The former tends to be the more horizontal of the two. Records are kept of the flowering habits of the trees, all of which have produced male and female flowers and set cones by the age of ten and in some cases much earlier. Some trees at this age are considerably heavier cone bearers than others. Three plus-trees are now producing four cone whorls on each fertile branch with up to five cones in each whorl, compared with others which give one or two whorls with fewer cones per whorl. The cones remain on the trees a number of years and it has been possible to trace over the last three years a consistent pattern which may continue into adult life. A fairly common undesirable characteristic which is apparent at an early age is the occurrence of persistent cones arising directly from the main stem.

White bands have been painted on each plus-tree at breast height, 15 ft., 25 ft., and 35 ft. The girths and bark thickness at these heights and the total height are measured at the end of each growing season. Eighteen plus-trees have been selected for inclusion in a clonal trial. Some of them do not compare very favourably with the best trees, particularly in respect of vigour, but they have been included so that the pool of genetic material is not too small.

VEGETATIVE PROPAGATION

Cuttings, air-layering and various types of grafting have been employed as a means of propagating selected plus-trees to obtain material for a clonal trial. Reference should be made to papers by Mergen and Rossol (4) and Mergen (3) for information on the propagation of *P. elliottii* Engelm, a species closely related to *P. caribaea*.

AIR-LAYERING

Air-layering consists of removing a cylinder of bark about half an inch long, preferably just below a node and about 15-20 ins. from the end of a branch. If used, hormone is 'painted' on the branch above the upper cut with a fine brush. The cut zone is covered with moist moss and wrapped in a polythene cover which is tied at each end to retain moisture. After 3-4 weeks, small roots have usually developed but this stage may extend to 12 weeks. Rooting response varies considerably between different trees and even between branches in the same whorl on one tree. Rooted air-layers are not removed from the tree until vigorous roots are showing under the polythene. Excessive water in the moss has a detrimental effect on rooting. Occasional inspection of the air-layers is advisable in case birds have pierced the poly thene which must then be changed. Air-layering during the dry season has not given

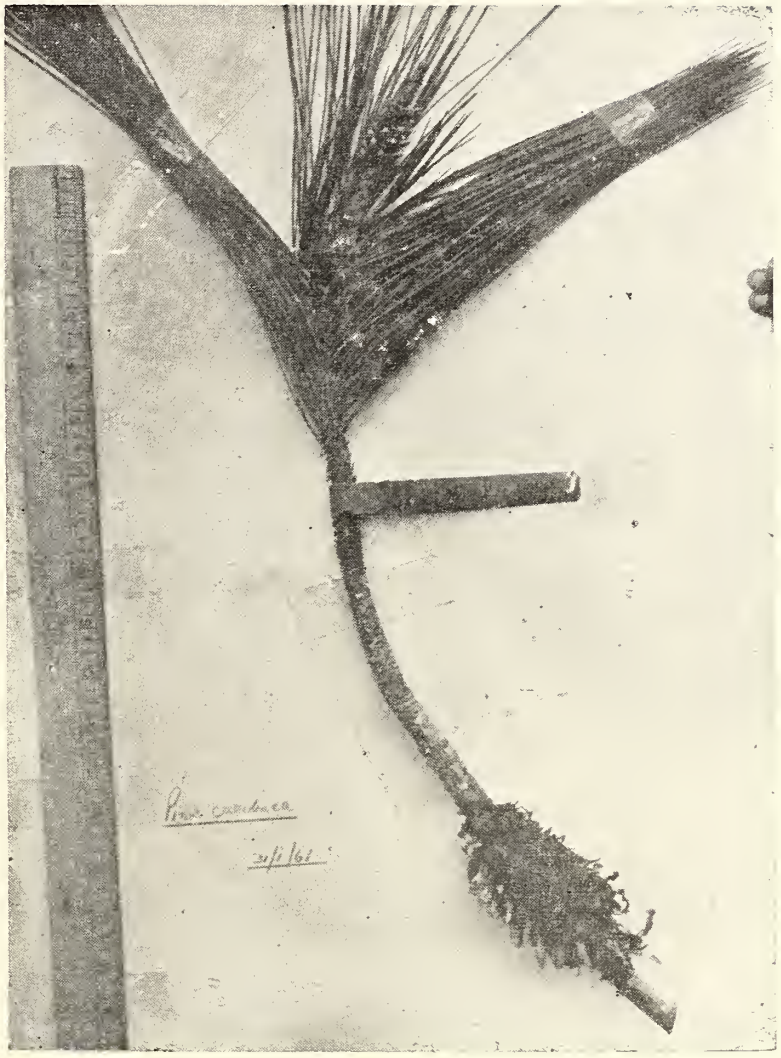

Figure 5. Air-layering of Pinus caribaea showing roots and adhering coconut fibers. Note male flowers.

good results, present indications are that the best period is August to October, after the first flush of the growing season has hardened off. First and second order branches appear to root with equal facility and there is some indication that rooting success increases with increasing height of the branch. In view of this, and to assist in the controlled pollination which is to be undertaken on some plus-trees, a thirty feet high 'portable' tower was purchased. It consists of 2 ins. diameter aluminium tubing in five and seven feet lengths connected with nut and bolt clamps. The tower, which is triangular in cross-section is erected by two men in just less than three hours. With the use of guy wires it can be extended to 60 feet. Of 185 air-layers prepared in 1960, 96 were treated with hormone (concentration as used with teak cuttings) and 89 were untreated. The rooting success was 54% and 26% respectively. With six plus-trees the average rooting success was over 60% while with another six, over the same period and conditions, it was below 30%. Branches bearing male and female flowers have been rooted and after potting

out male flower development has continued. Fertile branches rooted in 1960 did not produce flowers in 1961. The rooting success quoted has been obtained with trees 10-15 years old. A possible cause of poor rooting success, perhaps more so in the use of cuttings than of air-layers, is the copious resin flow frequently encountered when the stem is cut. This collects round the cut edge solidifying into an impervious mass. However, rooting success was not improved in one trial where cuttings were left overnight in running water. The rooted air-layers are transplanted into baskets using a potting mixture of peat moss, vermiculite and sand in the ratio 2:1:2. They are immediately inoculated with mycorrhiza and left to harden off in the propagation bin, before being placed in the open.

CUTTINGS

In view of the success of air-layering, investigations into the rooting of cuttings have been limited. Cuttings were prepared as described for teak, using core-baskets in a closed propagation bin. Sawdust was the only rooting medium used. In general, the rooting success has been much poorer. The best results were obtained with cuttings taken in May, two weeks before the start of the wet season. Cuttings prepared in September, October and November failed to root. The use of a hormone dip (as used for teak) appeared to be detrimental to rooting, only three of 102 treated cuttings rooted. In one untreated clone, five out of five cuttings were rooted but in general the rooting success was less than 10% and in several clones nil. Within two or three weeks, the cuttings with a weak solution of indolebutyric acid had no apparent effect on preventing needle fall. Raising the cuttings in a humidifier only slightly delayed the onset of needle fall.

GRAFTING

A number of approach, bottle, cleft and side grafts have been made in the field, with and without covers, and also a humidifier. Apart from one approach graft success has been nil, in spite of the fact that an expert fruit grafter shared the grafting with the writer. The copious resin flow mentioned above appears to hinder a close union between stock and action. In view of the value of grafting for large scale propagation, further investigations will be made to find a successful technique.

CLONAL TRIAL

A 1.5 acre site has been cleared in an area of natural forest, approximately two miles from the nearest pine plantation. This is now about half stocked with vegetatively propagated material from the eighteen clones being investigated. The layout is in the form of randomised blocks of single tree plots. There are twelve replications. Square spacing at 15 x 15 ft. has been used. It is the intention with both the pine and teak clonal trials to use the material for the purposes of seed orchards while genetic evaluation of the clones is underway, removing inferior clones as experience and progeny trials may indicate.

FLOWERING

No detailed studies have yet been made on the flowering of *P. caribaea* in Trinidad. Fresh male flowers have been observed in every month of the year though they are most abundant from November to January, the only period in which fresh female flowers have been observed.

PROGENY TESTING

In 1961, cones were collected from a number of open pollinated plus-trees. The amount of viable seed varied considerably from tree to tree. The seedlings are being raised following the usual nursery procedure and they will be planted out in 1962.

TIMBER TESTING

Since 1958, Trinidad forest officers have made the timber properties of *P. caribaea*, in particular the specific gravity/tracheid length relationship, the subject of their special

study in their post-graduate course at the Commonwealth Forestry Institute, Oxford. In 1958, material from British Honduras was used. In 1959, Trinidad grown material from three 8-year old trees was studied. In 1960, twenty 10 mm. diameter cores again locally grown were sent for study, the cores being taken at five feet ground level. Ten were from plus-trees, the other ten were taken from the nearest tree to each of the plus-trees sampled. No firm conclusions have yet been reached and no standard can be set for the purpose of assessing the timber quality of plus-trees selected in the breeding programme.

ACKNOWLEDGEMENTS

The Trinidad and Tobago Forest Department is grateful to the Faculty of Agriculture, I.C.T.A./U.C.W.I., St. Agustine, for the propagation facilities supplied. The writer in grateful to several members of the faculty staff for the useful discussions on vegetative propagation and related aspects of breeding work.

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Leaf Size in Swietenia

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SUMMARY

A study was made of the putative hybrid of bigleaf and small-leaf mahoganies. Initial measurements indicated that bigleaf mahogany can be distinguished from small-leaf mahogany by gross measurements of leaflets.

Isolated mother trees yield typical progeny.

Typical mother trees in mixed stands yield like progeny plus, usually, mediumleaf progeny.

Mediumleaf mother trees yield mixed progeny and usually yield all three types: bigleaf, small-leaf, and mediumleaf.

Although there must remain an element of doubt until hand pollination under controlled conditions is accomplished, it seems apparent that the mediumleaf mahoganies previously reported as hybrid between **Swietenia macrophylla** and **S. mahagoni** actually are hybrid.

For the trees observed bigleaf, small-leaf, and Pacific mahoganies can be separated on the basis of leaf venation.

RESUMEN

Se hizo un estudio del tipo supuestamente híbrido entre la caoba de hoja grande y la caoba de hoja pequeña. Las mediciones iniciales indicaron que la caoba de hoja grande puede distinguirse de la caoba de hoja pequeña haciendo mediciones de las hojuelas.

Arboles madres aislados producen progenie típica.

Arboles madres típicos en rodales mixtos producen progenie semejante; por lo general también producen progenie de hojas medianas.

Arboles madres de hoja mediana producen progenie mixta y generalmente progenie de los tres tipos: de hoja grande, hoja pequeña y hoja mediana.

Aunque existirá alguna duda hasta que se efectúe la polinización artificial bajo condiciones controladas, aparentemente la caoba de hoja mediana antes considerada como el híbrido entre la **Swietenia macrophylla** y la **S. mahagoni,** es en sí híbrida.

Según los árboles observados, la caoba de hoja grande, la caoba de hoja pequeña y la caoba del Pacífico pueden distinguirse basándose en la venación de las hojas.

For several years there have been reports (Stehlé 1946, Tropical Forest Research Center 1960, others)[2/] of a putative hybrid between small-leaf mahogany (*Swietenia mahagoni* Jacq.) and bigleaf mahogany (*Swietenia macrophylla* King), based chiefly on leaf size. An attempt was made to determine whether the assumed differences actually exist.

LEAF SIZE

The first step was to collect a number of leaves from "typical" trees of each species for measurement and observation. One leaf was taken from the crown, two-thirds of the way up, of each of three trees of each species. From this leaf, the three central leaflets on the right-hand side of the rachis were taken for measurement. In addition to the two better known species, Pacific mahogany (*S. humilis* Zucc.) was also measured. Results are shown in Table 1.

It was gratifying to find the leaflets of bigleaf mahogany so consistently longer and wider than the leaflets of small-leaf. In subsequent measurements sizes were found which

1/ Dr. Lamb is now with U. S. Plywood Corporation.
2/ Stehlé, H. 1946. Les types forestiers des isles caraibes. Carib. For. 7 (Supp. 2) 337-709.
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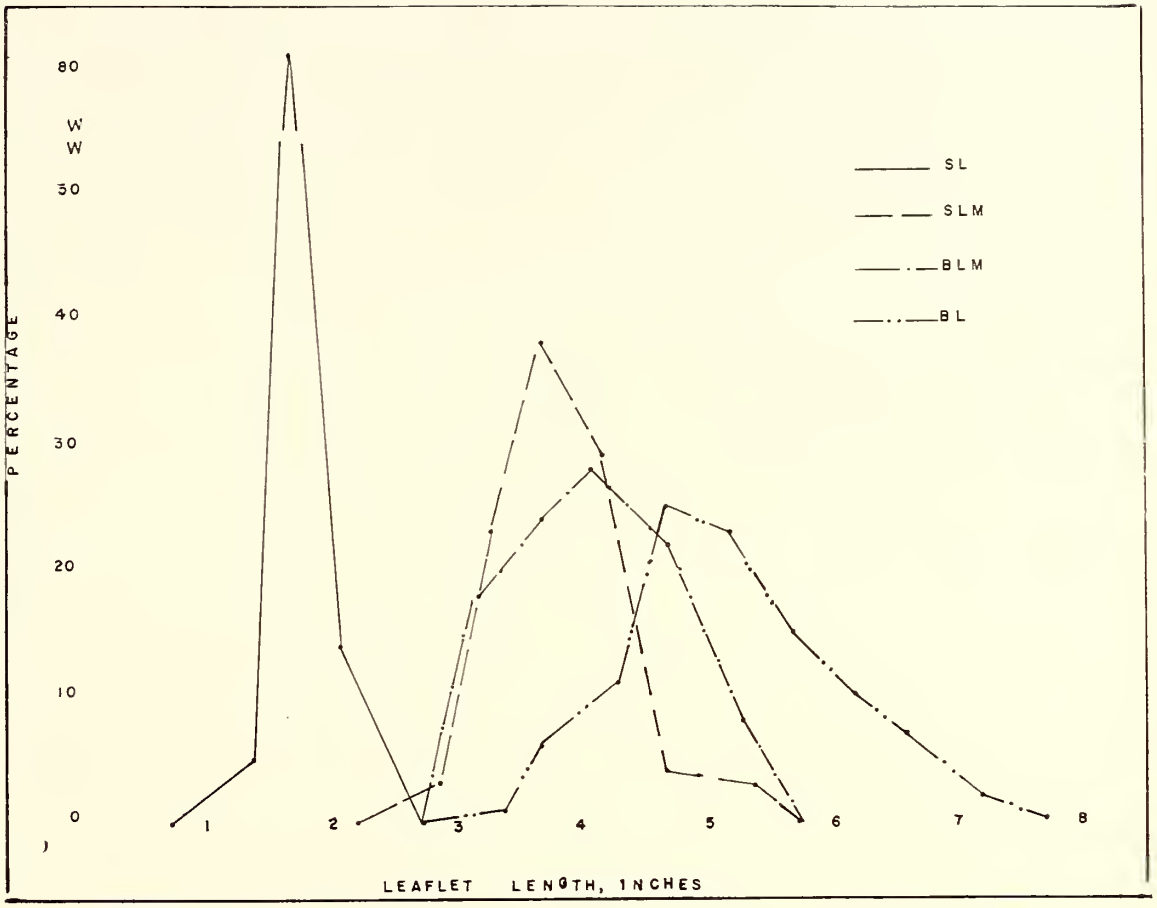

Figure 1. Percentage distribution of length of mahogany seedling leaflets; one leaflet measured per seedling. SL: Small-leaf progeny from isolated mother; SLM: Mediumleaf progeny from small-leaf mother; BLM: Mediumleaf progeny from bigleaf mother; BL: Bigleaf progeny from isolated mother. Measurements provided by R.W. Nobles. BLM based on 50 measurements, remainder on 100 measurement each.

do overlap, but mean leaflet length or width serves to distinguish objectively between the two species.

Unfortunately for tidiness, Pacific mahogany overlaps both the other species in all dimensions measured.

During this intensive comparison three other leaf characteristics were noted as distinguishing: prominence of lateral veins, prominence of edge veins, (veins forming a more or less continuous system near and essentially parallel to the leaf margin), and the shape of leaflet tip.

Small-leaf mahogany leaflets had no prominent veins and an acute tip. This last characteristic is indicated quantitatively by a relatively low ratio of maximum width to width one centimeter from the tip.

Bigleaf mahogany had prominent lateral and prominent edge veins, and had an acuminate tip. This last is shown by the high ratio of maximum width to tip width.

Pacific mahogany had a variable tip; however, it had prominent lateral veins —unlike small-leaf— and inconspicuous edge veins —unlike bigleaf.

Table 1. Measurement of leaves from "typical" mahogany trees

Prominent veins		Rachis length	Leaflet			Max. Width Tip width
			Length	Width		
Lateral	Edge			Maximum	1 cent. from tip	
		mm	mm	mm	mm	
			Small-leaf			
No	No	52	59	19	4	4.8
			40	14	7	2.0
			33	12	8	1.5
No	No	72	51	15	4	3.8
			47	14	6	2.3
			39	13	8	1.6
No	No	47	44	14	8	1.8
			41	12	6	2.0
			34	12	8	1.5
		Mean	43	14	7	2.4
			Bigleaf			
Yes	Yes	175	137	39	4	9.8
			131	47	3	15.7
			103	39	4	9.8
Yes	Yes	77	120	55	3	18.3
			85	33	4	8.2
			81	32	4	8.0
Yes	Yes	110	93	41	6	6.8
			92	33	5	6.6
			90	31	5	6.2
		Mean	104	39	4	9.9
			Pacific			
Yes	No	92	132	66	5	13.2
			96	40	4	10.0
			92	38	5	7.6
Yes	No	120	87	30	10	3.0
			73	36	10	3.6
			70	27	12	2.2
Yes	No	60	56	23	3	7.7
			50	17	5	3.4
			29	11	5	2.2
		Mean	76	32	7	5.9

In addition, Pacific mahogany had a more leathery, coarser-seeming leaflet than either of the other two.

PROGENY TEST

Once guide lines were established for objectively distinguishing between the two major species, seeds were collected from five types of mother trees and sowed in randomly selected portions of a single seed bed. Results are shown in Table 2.

Again, the initial results were so gratifyingly clear that further counts were unnecessary, although inspection of subsequent seedlots has confirmed them.

Seedlings grown from seed collected from isolated small-leaf mother trees yielded only small-leaf progeny. Isolated bigleaf mother trees yielded only bigleaf progeny. Small-leaf mother trees in mixed stands yielded small-leaf and mediumleaf progeny. Bigleaf mother trees in mixed stands yielded bigleaf and mediumleaf progeny. And mediumleaf mother trees yielded bigleaf, small-leaf, and mediumleaf progeny.

There are no trees of Pacific mahogany of seed-bearing size in Puerto Rico; therefore, no investigation was possible at this time.

Table 2. Number of progeny by leaf type, for each mother tree

Mother-tree Type	No.	Progeny Type			
		Bigleaf	Small-leaf	Mediumleaf	Mixed
Bigleaf, isolated	1	46			
	2	28			
Bigleaf, near small-leaf	3			76	
	4	33			
	5				27
	6				41
Small-leaf, isolated	7		100		
	8		38		
	9		96		
	10		35		
	11		60		
	12		31		
	13		38		
Small-leaf, near bigleaf	14		29		
	15	23	7	6	
	16				45
	17	17	11	47	
Mediumleaf	18				22
	19				30
	20	9	19	16	
	21				55
	22[1]/	39	236	3915	
	23[1]/	1021	9	20	

1/ Data provided by Division of Virgin Islands Forestry Assistance.

Tropical Forestry with Particular Reference To West Africa

by C. J. TAYLOR

Oxford University Press, London. 163 pp., 1962.

BOOK REVIEW

As stated in the preface, this book is prepared for "Forest Rangers in training and . . . others who wish to obtain an insight into the practice of tropical forestry. The attempt has been made to provide a generalized account so that the reader might have a sufficient understanding of forestry matters to benefit from the excellent books that are available on specialized subjects."

The book is excellently written to fulfill its purpose. Technical jargon is held to an absolute minimum, and discussions are kept simple with no clutter of unnecesary detail. Typical is his description of administration which presents a clear, succinct description of British administrative organization, and as such is especially useful to North American or other non-British foresters who may be visiting former British colonial areas.

Two pages devoted to the management of bamboo should be memorized by the ingenuous farmers, foresters, and politicians throughout the tropic and subtropic regions of the world who are continually "discovering" bamboos. Possibility, it is; foolproof, it certainly is not.

Finally, his description of education and research contains one of the clearest and shortest expositions of the experimental method ever printed:

(a) try everything that seems reasonable
(b) select what is practicable
(c) work out an economic technique.

Tropical Forestry, by Dr. Taylor, is recommended as required reading for every subprofessional course being taught in this field.

CHARLES B. BRISCOE

double-spaced typewritten pages, although an occasional longer article of special interest may be acceptable. Articles should be submitted in the author's native tongue, and should include title or position of the author as well as a brief summary of the material. Manuscripts should be typewritten, double spaced, on one side of the page only, on 8½ x 11 inch white bond paper.

Tables should be numbered consecutively, each on a separate sheet with a title. Footnotes used in tables should be typewritten as part of the table and designated by numerals.

Illustrations should be designated as figures and numbered consecutively. Captions for each illustration should be submitted on a separate sheet. Photographs submitted for illustrations should be clear, sharp, and on glossy paper, preferably 5 x 7 or 8 x 10 inches in size.

Footnotes should be numbered consecutively, with a superior figure placed after the word in the text to which the footnote refers. The footnote should appear in the text in the line following the reference number, separated from the text by a short line running inward from the left margin of the text. Footnotes are used to give credit to unpublished material and communications. If only a few references to literature are made, literature citations may be placed in footnotes. Literature citations should include the author, year published, title of the work cited, name of publication, and pages.

Manuscripts should be sent to the Director, Institute of Tropical Forestry, Rio Piedras, Puerto Rico.

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Le "Caribbean Forester" est une revue semiannuelle qui a été publiée depuis l'année 1938 en Puerto Rico por le Institut de Foresterie Tropique, Service Forestier du Départment de l'Agriculture des Etats-Unis. Cette revue est dediée a l'aménagement et a l'utilisation des forets surtout dans la region caraibe.

Par les pages de cette revue les personnes qui travaillent aux tropiques peuvent etre informées sur les problemes specifiques des forets tropicales et sur les travaux effectués pour realiser une ameilloration technique par l'aménagement et l'usage des resources forestiéres. Cette revue pourvoit aussi un moyen de destribuer l'information et les resultats obtenus par le programme experemental du Institut de Foresterie Tropique de Puerto Rico; en plus cette revue offre ses pages a les autres travailleurs forestiers des pays tropicaux pour qu'ils purssent publier les resultats de leur travaux.

Cette revue accepte volontiers des contributions ne depassant pas 20 pages dactilografiées a double espace, cependant que certains travaux du intéret spécial plus long purvent etre acceptés. Les contributions doivent etre ecrites dans la langue maternelle de l'auteur et doivent bien preciser son titre et sa position professionnelle, l'appert doct etre accompagné d'un résumé de l'étude. Les manuscripts doivent etre dactilografiées en double espace su du paper 8½ por 11 pouces.

Les tables du travail doivent etre numerotées en ordre sur page separée et les notes au pied de ces tables doivent etre dactilografiées, comme une partie du table.

Les illustrations doivent etre designées avec des numeros consecutifs. Les titres de chaque illustration doivent etre sumis sur une page separée Les photographies comme les illustrations doivent etre bien claires, bien definies et sur papier glacé preferablement 5 x 7 pouces au 8 por 10.

Les notes au bas de la page doivent etre numerotées apíes le mot qui fait reference a la note. La note au pied devra aparaitre dans le texte sous la ligne qui suit le numero de reference, separée de texte par une ligne courte couront de gauche a driole de la marge du papier. Les notes au pied sont usées pour faire honneur aux travaux qué nónt pas été publiés. Si on fait seulement quelques-unes reference quá la litterature pauvent designée les comme notes au pied. Citation au litterature publiée doivent comprendu, l'auteur, l'année publiée, le titre du travail, le nom de la revue et les pages de cette revue.

Les manuscripts doivent etre evnooyés a: "Director, Institute of Tropical Forestry, Río Piedras, Puerto Rico."

Nous voulons rappeller a nos lecteurs que les opinions expumées dans cette revue ne sont pas necessairement les opinions du Forest Service et que les articles publiés dans la revue le "Caribbean Forester" peuvent etre reproduits mais doivent jaire reference a cette revue.

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